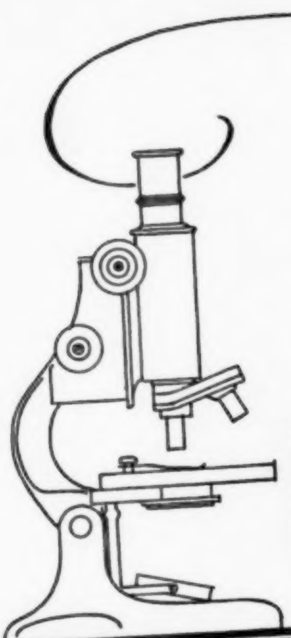

The SCIENCE COUNSELOR

A Quarterly Journal for
Teachers of Science in
the Catholic High Schools

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The Science Counselor

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IT'S TIME FOR ACTION—OR ELSE!

Ruthless Depression has had many a school laboratory "down for the count" of six long years . . . sluggish years in which the devitalizing forces of dwindled equipment have been actively at work retarding the rightful progress of students and instructors alike. This irreparable damage is enough to cause serious alarm and prod into action those who are at the helm of this vital branch of learning. Whether or not your laboratory felt the full force of depression's blow, you cannot afford to overlook the reviving and progressive merits of new, up-to-date apparatus and supplies. The depression—unwelcome as it has been—has taught shrewd science instructors that the suppression of laboratory wants and needs is not a virtuous conservation of funds. For, these things represent far greater security to the instructor, to the student and to the school than their equal in cash in the bank. Accordingly, you owe it to yourself to reach for your Milvay Catalog. It gives you compactly and systematically summarized, the complete line of Milvay values and you can depend on it as your sole source of supply.

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Safety in the Chemical Laboratory

● By I. J. Wernert
DEPARTMENT OF CHEMISTRY, NIAGARA UNIVERSITY

When proper care is taken in advance, practically all laboratory accidents are avoidable. They need not happen. They must not!

Industry has learned its lesson. Schools should do likewise. Professor Wernert has had experience in commercial as well as in teaching laboratories. He knows whereof he speaks when he says safety is preferable to first aid.

This carefully written article may save lives.

●

A splendid article, "And Sudden Death," which has recently been published on the need of safety in the driving of motor vehicles, is familiar to nearly everyone and has provided one type of model for all safety discussions. It would not be inappropriate to follow this model and to devote an entire paper on safety in chemical laboratories to a description of the tragic results which follow when experiments, such as are carried out every year in high school courses, are conducted with a disregard for a few simple safety regulations. Such a description would not make pleasant reading unless one considers it pleasant to read about bloody fingers and painful burns or blinded eyes, not to mention serious infections developing from minor accidents considered "too small to bother with."

Regardless of whether it is pleasant reading or not, accidents which could be easily prevented do happen both in high school and college laboratories and sometimes end with dreadful results. Among others, the writer has seen the permanently blinded victim of an explosion which occurred when a can of sodium was accidentally pushed into a sink, and he has seen a student carried to an ambulance after his lungs had been bathed in bromine vapor and his body had been horribly burned by the liquid. A continuation of this topic might have the highly undesirable effect of securing safety in the wrong way, namely, by discouraging further work in the laboratory.

Chemistry is an experimental science and it is generally agreed that it can best be taught with the aid of well chosen experiments carried out by the students themselves. Unfortunately, it does not appear to be so well agreed that these experiments can and must be carried out safely.

E. C. Buxbaum, however, in commenting on safety (*J. Chem. Educ.*, 11, 73, 1934), writes:

"Accidents in the chemical laboratory are as avoidable as other accidents are. The few times when accidents are due to wholly unforseen causes which might be classified as "Acts of God" are no more numerous than in any other profession. The accidents which occur in chemical laboratories are, almost without exception, avoidable with care."

A chemistry laboratory is admittedly a potential source of accidents and the ideal of 100% safety is never reached for more or less obvious reasons. This does not in any way excuse the present laxness existing in many high schools and colleges.

There is a great deal of difference between the teaching point of view and that of industry toward safety. The teaching attitude of "it hasn't happened yet" would not be tolerated in an industrial laboratory where an accident means not only lost time but the possibility of a heavy damage suit in addition. Frederic Walker well expressed the industrial point of view (*J. Chem. Educ.* 11, 506, 1934), when he wrote:

"Industry has learned the lesson of safety at the price of bitter experience and demands today that its chemists be safe workers.—An industrial chemist must know the safety rules and follow them. If he cannot do these things his employers cannot afford the risk of retaining his services."

The attitude of industry ought to be carried over and applied to laboratory teaching in universities and in high schools where it should have been fostered in the first place. Although it is recognized that damage to limb or eyesight cannot be measured in terms of economics alone, occasional damage suits (two of which are reported in *J. Chem. Educ.* 10, 552, 1933), should impress teachers with the seriousness of accidents from a purely financial point of view. In both of these cases, high school pupils received awards of $16,000 for the loss of an eye. A remark made by one of the attorneys to the effect that "it is better to leave a boy uneducated than it is to blind him" deserves the utmost consideration of every teacher in chemistry.

A complete discussion of possible unsafe practices in high school chemical laboratories would be almost an impossible task. There is no substitute for good judgment and common sense on the part of the teacher. Each experiment has its own set of dangers and should be analyzed from the standpoint of safety before giving it to the class. There are, however, several important topics of a general nature which deserve attention.

One of the problems which confronts every high school teacher of chemistry is that of fire. The laboratory should be equipped not only with a fire extinguisher but also with a shower bath and a wool blanket folded so that it may be completely opened with one jerk. In practice, it is sometimes difficult to secure both of the latter facilities but no laboratory should be operated without the protection of either one or the other. The instructor should insist that the burners be operated at reasonable heights not only because of good

technique but also because of the fire hazards involved. Most high school courses are not concerned with many organic chemicals but occasional class experiments dealing with benzene, the very inflammable carbon disulfide or ether, and other similar compounds deserve special precautions. It might be well to point out in this connection that small fires on chemical apparatus may be easily extinguished by means of a rag or towel pushed down on the apparatus so as to exclude air.

Burns from acids are dangerous and should be prevented. A source of ever present worry to the conscientious teacher is concentrated sulfuric acid which has such a high affinity for water that it extracts it from organic tissues of the body with which it comes in contact, thereby producing slow healing and painful lesions. It is wise to supply high school pupils with dilute acid unless the experiment requires the concentrated form. Too much emphasis cannot be placed on the fact that concentrated sulfuric acid may be diluted safely only by slowly adding the *acid to water*. The writer's attention has been called to an accident which occurred with the loss of both eyes when the opposite method was employed. If sulfuric acid is diluted by the student, it should be prepared only after very careful directions have been issued by the instructor immediately prior to the act. Nitric acid, although usually not as troublesome as sulfuric acid, eventually causes the skin to peel and sometimes opens the way to infection. The corrosive action of hydrofluoric acid is frequently accompanied by little pain until it has penetrated deeply. This acid should not be handled by high school pupils. Hydrochloric acid and dilute acetic acid require no extraordinary technique in their use and are comparatively safe, but contact of the skin with all concentrated acids should be avoided.

Caustic burns are less common than acid burns but may be severe. A solution of alkali usually does more damage to wool clothing than to anything else unless it comes in contact with the eye. Metallic sodium, however, combines the qualities of a super-alkali with its own explosive action on water and should be issued to high school pupils, if at all, in quantities not exceeding the size of a pea. The stock of sodium itself should be kept in a closed container covered with kerosene, out of possible contact with water, and should be inaccessible to anyone but the instructor.

All acid and alkali burns, if they do occur, should be thoroughly flushed with plenty of water. Speed is essential when an eye is involved. There is no time to be wasted on eye cups or other specialized equipment. A wash bottle may be conveniently used if it is handy but water dashed in the eye from a beaker will accomplish the same end. It is permissible to treat alkali burns with a solution of boric acid and acid burns with sodium bicarbonate solution, but only after they have been well washed with water. All chemical burns require bandaging and preferably should be treated by a competent physician.

Undoubtedly the greatest source of minor accidents is found in the faulty manipulation of glass tubing. Simple rules should be formulated and the instructor should insist that the pupils follow them implicitly. For example, such rules should include the following:

1. Fire polish the ends of all tubing.
2. Have bore of stopper sufficiently large for the size of the tubing.
3. Use water, or soap and water on the tubing as an aid to inserting it into the stopper.
4. Grasp the tubing close to the end to be inserted.
5. Twist the tubing as it is gently forced through the stopper.

It is advisable to have a pair of cotton gloves available to be used in cleaning up broken glass. All glass cuts should be carefully inspected to make sure there is no glass in the wound before applying bandages. Unfortunately a first-aid kit to take care of small injuries arising from broken glass and other similar causes, is necessary in many high schools where a nurse is not immediately available. The dressing and disinfectants contained in such a kit as well as their uses are familiar to everyone but it should be pointed out that even minor injuries deserve skilled attention and more serious ones must have it. It is hardly necessary to mention that painful burns are often caused through handling hot bends, etc., because the instructor usually bears the brunt of this attack. As a matter of self defense, the writer has found it necessary to mentally tie his hands behind his back while inspecting the results of efforts made to bend glass which will meet with his approval.

Eternal vigilance should be the watchword of every teacher in the laboratory. It is really surprising to read the average manual and note the few safety precautions which it contains. Many texts do not warn against the poisonous properties of hydrogen sulfide when prepared even in small quantities without the benefit of a hood and in a room lacking in ventilation. Few books suggest that the manganese dioxide used as a catalyst in the preparation of oxygen from potassium chlorate should be tested for organic matter by heating small quantities of it with the chlorate before giving it to the class. Some manuals even fail to mention that hydrogen generators should be wrapped with a towel in order to eliminate danger from flying glass and acid in the event of an explosion. The vigilant instructor will supply safety rules of this sort and provide proper penalties to insure their observance. It should be pointed out in this connection that even the simplest of instructions whether written or oral are subject to misunderstanding on the part of the student. In an actual case, for example, a pupil was attempting to follow direction in the preparation of sodium hydroxide solution and was stopped by the teacher as he was about to add forty grams of sodium to an appropriate quantity of water. The careful instructor in the high school will see that very dangerous chemicals such as arsenic, cyanides, yellow phosphorus and the already mentioned metallic sodium are either among the missing or are under lock and key.

Continued on Page Fifty-six

A Mendel Relic Comes to America

● By Samuel W. Fernberger, Ph.D., *(University of Pennsylvania)*
PROFESSOR OF PSYCHOLOGY, UNIVERSITY OF PENNSYLVANIA

When an American university receives for its museum a valuable Mendel relic, it is news. The story of how it came here is a most interesting one.

Professor Fernberger's sketch of Mendel's life, his home and his researches will appeal to every worker in science.

It is inspiring to read of a research of the first magnitude accomplished as was Mendel's without extensive libraries, laboratories, apparatus and equipment.

●

On February 15, 1936, the author had the honor to present a specimen from the herbarium of P. Gregor Mendel to the University of Pennsylvania in the name of the Augustinian Monastery of St. Thomas in Brno, Czechoslovakia. This specimen consists of a part of a plant of the edible pea—with stem, a few leaves and some flowers. This plant was saved by Mendel, as a type specimen, in his famous experiments by which he formulated the ratios of inheritance of characteristics in hybrid breeding. These experiments and their results are so well known that it is almost commonplace to state that they have become the basis of the new science of Genetics and that they were necessary to give meaning to the theory of evolution as expounded by Darwin.

An examination of the photograph of this Pennsylvania specimen indicates that the plant shows signs of wear and tear. The methods of preserving botanical specimens were not as advanced in the 1860's as they are today. Considering that this dried plant is over 70 years old, it is surprising that it is in as good a state of preservation as it is at present. One cannot say with assurance to which of the seven experiments this specimen belongs. From its size—if this is most of the plant—it may have come from Mendel's experiments with the inheritance of plant stature and, in this case, this specimen would have been preserved as an example of dwarf stature. On the other hand, it may have been preserved as a type of experiments which had to do with the inheritance of the position of flowers on the stem.

This specimen of Mendel's work has become a notable addition to the historical-scientific collections at the University of Pennsylvania which contain many objects used by Benjamin Franklin, and Benjamin Rush, glass from the laboratory of Louis Pasteur, and many other objects of scientific association.

The University of Pennsylvania specimen of the plant of the garden pea saved by Mendel as a type in his cross-breeding experiments. This specimen consists of stem, leaves and flowers and is authenticated by the seal of the Monastery.

My acquiring of this specimen for the University of Pennsylvania may not be without some interest. Nearly five years ago, I visited my very good friend and former teacher, Dr. Frederick M. Urban, who was formerly professor of psychology at the University of Pennsylvania and under whom I did much of my graduate work. He now resides in the city of Brno, Czechoslovakia, which was called by its German name of Brünn before the war when it was included in the Austro-Hungarian Empire. Today Brünn (Brno) is the second largest town in the Czechoslovakian Republic. It is near Austerlitz and, indeed, after his success in the Battle of Austerlitz Napoleon slept that night in Brünn.

Near the center of the town is an isolated hill called the Spielberg on which are extensive fortifications used, until shortly before the war, as a prison for political prisoners. The old town, still called Alt-Brünn, lies at the foot of this fortified hill. Near the foot of the Spielberg lie the church and buildings of the Augustinian Monastery of St. Thomas. As can be seen from the photograph, both are of strong, simple and very beautiful architecture. The cloister is built in the form of a hollow quadrilateral inside of which is a garden. It is part of this garden which was set aside for Mendel's use for his experiments. The actual garden space available is surprisingly small.

Johann Mendel was born July 22, 1822, in the corner of Moravia close to where the present German, Polish and Czechoslovakian frontiers come together. After schooling near his place of birth, he was accepted as a novice in the St. Thomas Cloister in 1843—at which time he assumed the name of Gregor—and in 1847 he was ordained a priest. For several years he acted as parish priest but turned then to study and teaching which occupied him until, in 1868, he was elected Abbot and Prelate of the St. Thomas Monastery. During the years 1851-1853 he was a student at the University of Vienna.

Mendel's interests ran in the direction of what was then called Natural Science which included physics, chemistry, zoology, botany, geology and what not besides. Mendel's particular interests were primarily in the field of botany and agriculture but he was also interested in astronomy and in meteorology. He published one paper on sun spots and for

many years, contributed daily observations from his own meteorological station in Brünn.

When Mendel came to St. Thomas Monastery, he found an atmosphere congenial to his tastes and interests. For many years there had been a tradition of interest in science and art. Prelate Napp, who was then Abbot, encouraged the young Mendel in his studies and his experiments, making available time, space and materials for their furtherance, and sending Mendel to Vienna for study when it became obvious that more formal study was needed.

Mendel's active research period was from 1856 to 1871 and he was engaged in plant breeding experiments during this entire period. The work on the inheritance of seven pairs of characteristics was completed by 1866. The results of these ten years of experimentation were incorporated in a paper read before the Brünn Society for the study of Natural Science. No member of the Society seemed particularly interested in the results, probably because no one really understood the real significance of Mendel's report. There is a record that about 120 copies of the Proceedings of the Society were sent as exchanges to other societies, scientific academies and universities and that Mendel himself was given approximately 40 reprints of his paper.

Thus the paper received a fairly widespread notice for that day, but again no one seemed interested in Mendel's results even though the paper must have been read by a number of individuals interested in problems of hybridism. In spite of this failure to interest his botanical colleagues, Mendel continued his experiments. On the advice of a botanist, Carl von Nägeli, Mendel switched in 1867 from the utilization of the edible pea—which was a most suitable plant for his purpose—to the hawkweed—which turned out to be a highly unsuitable plant. The result was that his last four years of research were extremely unproductive. In 1871 Mendel's duties as Abbot became so burdensome that he was forced to stop his experiments entirely. Heavy monastic duties apparently hastened his end so that Mendel died in 1884 when only 62 years of age.

Mendel's fame as a scientist rests upon his 1866 paper. We have already noted that its reception was cold within the Society at which it was read. Also there was no apparent interest on the part of botanists throughout the world who may have seen it. As a result it was completely forgotten—"buried" as a paper may so easily be when printed in the Proceedings of a small and unimportant Society unless it gets immediate notice elsewhere. In the last years of the 19th century a Dutch botanist, Hugo de Vries, was working on the inheritance of characteristics of hybridism when he ran across Mendel's 1866 paper. From that time on de Vries' work became largely a verification of Mendel's published ratios which he found to be completely correct. Because of this earlier work, de Vries in a paper published in 1900, named these findings the Mendelian Laws of Inheritance.

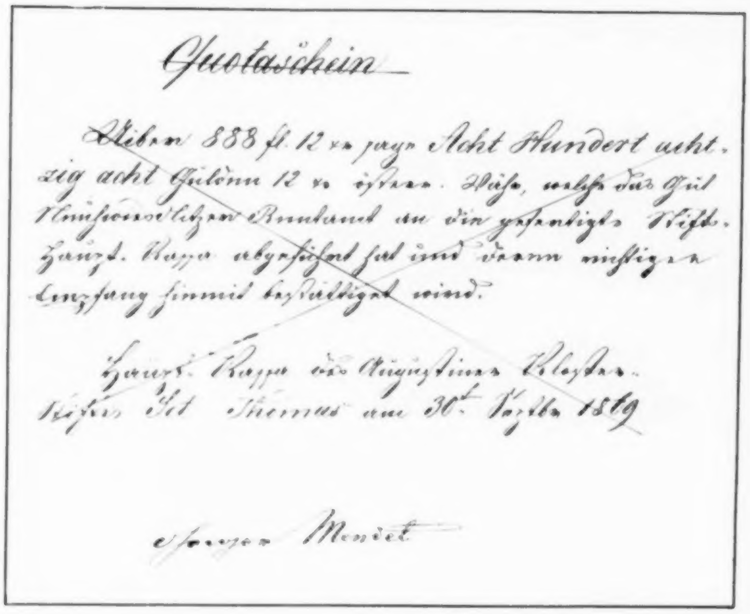
Thus not until 34 years after publication and 16 years after his death, did Mendel gain the recognition which was his due. Today his name is honored wherever there is knowledge of or interest in problems of genetics. He has become honored in his town of Brünn both within and without the Monastery in which he spent so many years. In the public square facing the Monastery of St. Thomas, a statue of Mendel has been erected. This depicts him in his ecclesiastical robes but bare headed. Within the garden in which his experiments were performed has been erected a monument which tells in four languages—Czech, German, French and English—that it was here that Mendel worked out his genetic law.

Within the Monastery buildings, Mendel's private rooms have been set aside as a museum. Here have been collected all of the possessions and materials connected with him and his work. One can see his portrait painted when he was Abbot and Prelate, his microscope and telescope, letters both private and scientific, photographs, copies of all of his published papers and the like. Most unfortunately, practically all of his scientific note books were destroyed shortly after his death—apparently by his own orders.

When I visited this Museum five years ago, I was most impressed to find that some of the actual specimens of the plants raised in his experiments had been preserved and were to be seen under glass. During a visit to Brünn last summer, I suggested to Dr. Urban what a fine thing it would be if a specimen plant could be procured for the collections at the University of Pennsylvania. Dr. Urban's brother, Mr. Eduard Urban, also a prominent citizen of Brünn, volunteered to approach the Fathers to see if a specimen could be obtained. He discovered that only six duplicate specimens had been preserved; that a rule had been made that only duplicate specimens could ever leave the Monastery and that three of these six duplicate specimens had already been given away. Mr. Urban so well presented the case of the University of Pennsylvania that the Fathers consented to part with this fourth duplicate specimen. It was prepared, with the seal of the Monastery, by P. Anselm Matauschek, the Curator of the Mendel Museum. He also presented the University with one of the very rare Mendel autographs which is also reproduced here. It will be seen that this is a receipt for the payment of certain rents signed by Mendel as Abbot in the year after his election but during the time when he was still continuing his experiments on hybridism.

It will be realized that this specimen is of the utmost rarity. Considering its fragile nature, the fact that so many of Mendel's scientific remains were destroyed after his death and especially considering how little his results were appreciated until after his death, it is really remarkable that any specimen should have been preserved at all. This dried plant is a symbol of research of the first magnitude performed without extensive apparatus. With only a small plot of unused garden, a few common garden tools and a handful of dried peas, but with infinite imagination, with the utmost care and perseverance Mendel worked out one of the great laws to be found in the history of science.

Mendelian Memorabilia



Quotaschein

Ueber 888 fl. 12 kr. sage Acht Hundert acht-zig acht Gulden 12 kr. österr. Währ., welche das Gut [illegible] [illegible] an die gesetzliche Stifts-Haupt-Kassa abgeführt hat und deren richtiger Empfang hiemit bestätiget wird.

Haupt-Kassa des Augustiner Kloster-Stiftes St. Thomas am 30. Septbr 1869

Gregor Mendel

● ABOVE

The Mendel autograph presented to the University of Pennsylvania. It represents a receipt signed by Mendel as Abbot.

● LEFT

Gregor Johann Mendel

● BELOW

The Augustinian Church and Cloister of St. Thomas in Brno, Czechoslovakia. The experimental garden of Mendel was inside the courtyard of the building to the left.

The Science Demonstration

• By Raymond B. Brownlee
STUYVESANT HIGH SCHOOL, NEW YORK CITY

This article should not be read.

It should be STUDIED.

As co-author of the highly successful and widely used textbooks, First Principles of Chemistry and First Principles of Physics, Professor Brownlee is well known by name at least to every teacher of high school science. His books are clearly written, practical, informative and interesting.

So is this article.

As you read it you will get a vivid picture of this author-teacher in action. You will realize what a privilege it would be to observe Professor Brownlee at the demonstration table.

•

It was the science demonstration that first awakened popular interest and enthusiasm for science. The experimental lectures of Davy and of Tyndall created a furor which it is hard for us to realize in an age in which science is a commonplace. Laboratories were few in the nineteenth century, but good demonstrators many. A decline in student interest in science came in the nineties with the mistaken idea of *replacement* of demonstrations, particularly in physics, by a narrow and rather infertile group of laboratory experiments. So deep did the resulting prejudice against physics become that, since the beginning of the present century, it has had a constant struggle to maintain its proper place in the curriculum. And this in a "Scientific Age!"

There are, however, few live science teachers who do not recognize that demonstrations and laboratory work are complementary. The special place of the demonstration is in the introduction of a new topic. Here it awakens interest, challenges the student, and arouses the desire to further pursue the topic through the study of a text and individual handling of apparatus in the laboratory.

The golden key to success in demonstration is preparation: long, thorough, untiring, persistent experimentation by the teacher who is to give the demonstration. No matter what help he has from others in assembling or constructing the apparatus, it should be the demonstrator himself who finally sets it up and tries it out again and again. Often what seems to be a brilliant inspiration for an experiment will fail when it is tried.

It has been the privilege of the writer to have been associated for more than twenty-five years with a master of demonstration, Dr. Ernest R. von Nardroff. With all the heavy duties of principal of a large high school, he took scores of hours each term in the preparation of an auditorium science demonstration. These were models of expert manipulation and clear, simple presentation. He has said many times: "If they could see me in my preparation room trying, failing, changing, and abandoning experiments, they would say I was the worst experimenter in the world."

It might be a mistake to so strongly emphasize the strenuous character of the preparation of a demonstration, were it not for the fact that science teachers are far from being lazy. If they were, they would not be science teachers. The eager response of our classes to well performed experiments, the glow on their faces, is ample payment for all our toil. When a successful experiment has been once prepared, it may be repeated with much less labor. The apparatus may well be used by another teacher, provided he has practiced with it beforehand until the experiment has become his own.

What shall be shown in the demonstration? The selection of experiments calls for discrimination, for they should be the best that can be presented with the apparatus available and the time which the teacher can devote to their preparation. In the first place, each experiment should be simple and so distinctive that it will stand out as an entity in the minds of the pupils. The apparatus should not be so complicated that the pupils cannot see the experiment for the apparatus. A large, imposing lecture table balance, with an elaborately trussed beam, may distract the attention of the students from the "cylinder and bucket" for Archimedes' principle, or the flask of air which is being weighed, and make them miss the essential reasoning.

It is well to avoid apparatus which may be used for a great variety of experiments. The purchase of such apparatus is, in my opinion, poor economy, for the different experiments for which it may have been used are very likely to be confused in the students' minds later on. Measuring instruments form important exceptions to this principle. Meter sticks, balances, and electric meters can and should be used repeatedly, since by their frequent use the reading of their scales becomes more familiar, and they sink to their proper place as mere measurers.

Groups of simple experiments are often desirable. In each, one aspect of the problem is presented and solved. Thus the final concept is reached step by step, which is the scientific way of leading to a generalization. Series of experiments in magnetism, static electricity, or expansion by heat are cases in point.

The old definition that an experiment is "a question put to nature" carries with it the thought of challenge. By the time pupils reach the secondary school, they have accumulated a considerable amount of scientific information and are often good scientific thinkers. Showing experiments which they have already seen or

done themselves, or demonstrating the obvious, are sure to bore a class, because they feel them to be an insult to their intelligence. I suspect that when we show a class some of the simple facts of magnetism, which they have themselves done in the elementary school, they think the teacher is not very bright. If you feel that an old concept needs reenforcing or clarifying, devise an experiment that shows it in a new and striking way. An experiment to be valuable must be thought-provoking.

Striking experiments do not simply mean "Oh my!" experiments. An electromagnet which picks up a drawerful of nails is better than one which picks up fifty brads; a real block and tackle with ropes and a fifty-pound weight makes a lasting impression not obtained from little brass pulleys threaded with fishline. Besides, it is easier to handle. The use of toys and an occasional resounding explosion is good, but the demonstration should not degenerate into vaudeville.

The demonstration experiment should be crisp, not tedious. A long experiment, involving a succession of quantitative readings, does not belong in the demonstration. It should be done in the laboratory, where the student's own activity relieves the tedium. Timing is as important in the demonstration room as in the broadcasting studio.

When we decry vaudeville, we should not forget that the arts of the stage are designed to get its message over to the audience. The successful demonstrator is something of a showman. So let us briefly discuss setting the stage.

An experiment which cannot be seen by all is useless. Far too much purchased apparatus is too small to be seen well by the boy on the back seat: steam engine models, for instance. A teacher with some knack with tools can often make apparatus which is much better than he can buy, because it is larger. The Hall of Science at Chicago was a liberal education to those science teachers who visited it. The two great lessons which it taught were size and lighting of apparatus. It is significant that modern science lecture rooms are equipped with floodlighting above the demonstration table, and sometimes with spotlights. A pair of show window reflectors with large bulbs, suspended from pulleys above the lecture table, are inexpensive and prove most helpful in illuminating the table. A hundred-watt bulb behind a cylindrical reflector of aluminum is tremendously useful in lighting up an ammeter scale, or some necessarily small piece of apparatus. This applies the principle that the visibility of a small object is directly proportional to its illumination.

The apparatus being shown should occupy the center of the table. If this is not possible, attention may be focussed on it by lighting, by screening other apparatus, or by separating the apparatus from other experiments as far as may be. It is well to go yourself to the extreme positions in the room after the apparatus is set up, in order to make sure it will be visible to every student. In using the optical disc and in other experiments in light in which the line of vision of each pupil should be normal to the apparatus, a turntable has been found very valuable. This is easily made from two boards, long and wide enough to hold the entire set of apparatus being shown; a brass rod fixed in the center of the upper board and fitted in a hole in the lower one, forms the pivot. With this turntable, the apparatus may be faced toward each section of the class in turn, with little loss of time.

In electrical work, important connections should be made before the demonstration. There are a number of useful time-savers. The ordinary attachment plug with a pair of flexible cords, preferably of different color, is useful for each connection which need not be made before the class. When it is desirable to show a change of connections during the experiment, spring binding posts and wires provided with solid tips make for neatness and dispatch.

If the teacher is a good blackboard draughtsman, as we all should be but sometimes are not, a simple outline or sectional diagram on the board, made during or immediately after the experiment, is a great help. For the less gifted, the substitute is a large chart prepared beforehand and hung up at the proper time. This has the disadvantage of not permitting the class to draw while you are drawing.

No matter how good the apparatus is, how well it is set up and lighted, the soul of the demonstration is the teacher. His art is to conceal art. His place is behind, not in front of the table, for he is an opaque object. The experiment and not the experimenter should bulk large in the pupil's eyes. Practice, practice, and still more practice will give that grace of performance which has been well defined as the art of doing a difficult thing in such a way that it appears easy. Do not attempt an experiment which you cannot do. While each demonstration is an experiment to the class, it should not be an experiment, that is a trial, for the teacher. Yield to every inspiration to try something new in the preparation room, but rarely do so before the class. Sometimes a bright pupil will ask: "What would happen if we did so and so?" Then the skillful teacher, who has anticipated such questions, will answer the question with the apparatus. Not infrequently he may discover that the suggested experiment is better than his, or shows a new and important angle. Here is a capital chance to apply the scientific method by cordially acknowledging the contribution. Thus the student and the class will see the scientific attitude exemplified.

Elbert Hubbard's admonition to never apologize holds true for any preventable failure in an experiment. But the most carefully prepared apparatus will occasionally go wrong. This situation calls for quick thinking and tact. If the trouble can be easily remedied, do so promptly, taking the class into your confidence as you work. If a major operation is necessary, explain briefly why this is so and proceed with the other experiments. On the next day show the experiment working as it should. Such frankness and enterprise will increase

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Changing Viewpoints in
Teaching High School Biology

• By Sister M. Dafrose, O.P., Ph.D., *(Fordham University)*
CHAIRMAN, SCIENCE DEPARTMENT, THE BISHOP McDONNELL MEMORIAL HIGH SCHOOL, BROOKLYN.

Sister M. Dafrose here begins a valuable and scholarly account of a century of progress in the teaching of biology.

The methods and objectives characterizing a period are shown by quotations from the most widely used textbooks of the time, and the changing thought of educators is followed from the natural history period of 1800 to the unit plan period of today.

The second part of this article will appear in the September issue.

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PART I.

Education has many aspects. One aspect is that of an ever widening circle of understanding through knowledge. Each year sees this circle of understanding embracing new phases of life, and with this experience comes a new and better grasp of the laws which govern the world of living things, increasing constantly our understanding of the myriad phenomena which surrounded us in our daily life. Today, the study of the biological sciences has no small part to play in this development of understanding through knowledge.

Biology offers to the high school student a new realm of interest, with new tools, and a new point of view. It unfolds the romance in the discoveries of great biologists like Mendel, Pasteur and others, who have done so much to benefit mankind, and whose persistent efforts in spite of failure, discouragement and lack of recognition, went on quietly and persistently day after day, year after year. The biological unit is the living individual. Biology studies fundamental facts about living things, giving knowledge about the interrelationship between man and the plant and the animal world. It shows the need of the conservation of plant and animal life and the means to improve them.

Through laboratory work there is furnished a means to rediscover facts already known and, perhaps, discover new ones. Through field work, interest in life processes is stimulated. The priceless value of health is emphasized by trying to establish habits of physical and mental well being. The study of biology may prove a means of vocational guidance by discovering student aptitudes and interests. Leisure could surely not be better employed than in the fascinating, healthful, outdoors to which biological studies give the key. Situations having direct bearing on home life, group conduct, human service, correct ideas about the relation of man to God the Creator, all aiding in building up a true ideal of citizenship, push into the frontiers of increasing understanding through knowledge.

Biology as a subject of study in the high school has a comparatively brief history. M. Payne, in an unpublished study on *The Place of Biology on the Entrance Lists of American Universities* (1924) states that the acceptance of any biological subject as entrance credit to college dates back less than fifty years. Its teaching passed through varying phases from the early natural history period, to the anatomical and morphological period, to the period of correlation and application of biology, down to its present day "unit plan" period. It may be of interest to take up in detail the varying viewpoints that determined the teaching of biology during the century of this progression, presenting as background the authors' ideas expressed in the texts in widest use at a particular period.

THE NATURAL HISTORY PERIOD

The biological sciences are usually understood to include botany, zoology and physiology. Botany formed part of the work of some of the academies, especially those for girls, from 1800 onward, but the subject was taught chiefly by foreigners and books on the subject were few and ill adapted to teaching. About 1820-1830 Eaton's *Botany* and Sumner's *Botany* came into use. Zoology, as a subject of study, found its way into the high school about 1825 as a natural history subject and was taught in about the same manner. Morse's *First Book in Zoology* (1875) shifted emphasis from natural history to morphology. Agassiz, that great and influential teacher, with his famous phrase "Study nature, not books," was the great zoology teacher of the period. His text which was widely used, intensified the transition. Physiology was the last of the trilogy to find its way into the high school curriculum and, like the botany and zoology of the period, was largely concerned with anatomy. Indirectly, it was the "Report of the Committee of Ten of the N. E. A." in 1892, that was responsible for the introduction of a few one-year courses in physiology. Indirectly this report was responsible in 1899 for the minority report of J. E. Peabody, the protagonist of physiology, who became responsible for what was later to become the New York State Regents' course in Elementary Biology. A still further impetus to the study of physiology was given by the Women's Christian Temperance Union which was powerful enough to have laws introduced in many states that made the teaching of the harmfulness of alcohol and narcotics mandatory in both elementary and high schools. The earliest teaching of these biological subjects might be characteried as the period of the natural history method.

THE ANATOMICAL AND MORPHOLOGICAL PERIOD

Asa Gray, professor of botany in Harvard College, published his first college text in 1842, but it was not

until 1858 that his text *How Plants Grow* was put into the hands of "Young people in the Common Schools." His influence which was far reaching, was exerted for nearly half a century. Those who recall the high school botany classes of thirty or forty years ago know that the subject concerned itself mainly with the anatomy and classification of flowering plants. Each student had to collect, press, preserve and label properly in an herbarium, a definite number, usually fifty, local varieties of "flowers." The study required an excellent memory for vocabularies, since the learning of numerous structural and descriptive terms for the various parts of the flowers was an essential part of the lessons, and the detailed anatomical studies of the flowers required their constant use. Asa Gray's text *How Plants Grow* was used almost exclusively until 1895, and even in the period 1896-1900 it was used in more schools than any other single text.

Another characteristic of the botanical study of this period was the idea of bringing the student to a better understanding of God through a study of the flowers He created. Three excerpts from Gray's text may be cited to illustrate this:

> "Consider the lilies of the field, how they grow; they toil not, neither do they spin; and yet I say unto you, that even Solomon in all his glory was not arrayed like one of these.—*Matthew vi, 28, 29.*
>
> Our Lord's direct object in this lesson of the Lilies was to convince the people of God's care for them. Now, this clothing of the earth with plants and flowers—at once so beautiful and so useful, so essential to all animal life—is one of the very ways in which He takes care of His creatures. And when Christ Himself directs us to consider with attention the plants around us,—to notice how they grow,—how varied, how numerous, and how elegant they are, and with what exquisite skill they are fashioned and adorned,—we shall surely find it profitable and pleasant to learn the lessons which they teach." . . . *(page 1).*
>
> "This book is intended to teach Young People how to begin to read, with pleasure and advantage, one large and easy chapter in the open book of Nature; namely, that in which the wisdom and goodness of the Creator are plainly written in the VEGETABLE KINGDOM." . . . *(page 2).*
>
> "*Paragraph 288.* In learning, as we have done, How Plants Grow, and Why they Grow, have we not learned more of the lesson of the text placed at the beginning of this book, and of the verses that follow? "Wherefore, if God so clothe the grass of the field, shall he not much more clothe you? . . . Therefore take no thought, saying, What shall we eat? or What shall we drink? or, Wherewithal shall we be clothed? For your Heavenly Father knoweth that ye have need of all these things." And we now perceive that causing plants to grow is the very way in which He bountifully supplies these needs, and feeds, clothes, warms, and shelters the myriads of beings He has made, and especially MAN, whom He made to have dominion over them all." . . .
>
> "*Paragraph 290.* In order that the vegetable creation might be adapted to every soil, situation, and climate, and to the different wants of the greatest variety of animals, as well as to the many peculiar needs of mankind, God created plants in a vast number of kinds. And in order that these should be perpetuated and kept distinct, he ordained that each should yield fruit and seed "after its kind." So each sort of plant multiplies and perpetuates itself from generation to generation." . . .

Bergen's *Elements of Botany* (Ginn and Co., 1896), shows the typical morphological trend of the latter half of the period. Anatomy and classification dwindled in importance and were succeeded by a subject which stood for an extensive terminology applied to organs that appeared under numerous disguises. The botany of that decade might well be spoken of as the morphology of reproductive structures. Bergen in his preface to the text defines morphology thus:

> "Morphology or the science of form, structure, and so on, deals with the plant without much regard to its character as a living thing. Under this head are studied the forms of plants and the various shapes and disguises which the same sort of organ may take in different kinds of plants, their gross structure, their classification, and the successive stages in the history of germs from which all but a few of the simplest plants are formed."

The subject was considered largely as a disciplinary subject. "The scientific habit of mind" was supposed to result from the systematic study of the subject, the careful laboratory work, the infinitesimal details of the drawings, the endless notes. Numerous laboratory manuals were issued, type forms were studied, and laboratory work in secondary schools reached a peak. The lower plants, algae, fungi, mosses, ferns were studied with great care, and laboratory notes and labeled drawings supplanted the herbarium.

H. R. Linville in an article on "Old and New Ideals in Biology Teaching" *(School Science and Mathematics,* X:210-216, March, 1910) speaking of this period says: "The teachers of morphological biology in the schools brought with them from the college certain ideals of method. Possibly the lecture method never took strong hold in the schools; but the laboratory method of the college with much of its paraphernalia did. The consequence of this was that thousands of young, untrained pupils were required to cut, section, examine, and draw the parts of dead bodies of unknown and unheard of plants and animals."

In the preface to the revised edition of Bergen's *Elements of Botany* (1904), we read:

> "This revised edition of the author's *Elements of Botany*, first published in 1896, is intended to retain all that was found most useful in the original book and to deal with a few topics somewhat more fully than was done in the first edition.
>
> The account of various types of germination and the discussion of the histology of the root, the stem, and the leaf of phanerograms have been somewhat curtailed. Experience has shown that those subjects were treated rather more fully than is necessary for a botany course of a half year or less. The topics (and a few others) in the present book may profitably be devoted to a somewhat more careful study of typical cryptogamic forms and an outline of the ecological classification of plants. Accordingly directions for the study of Bacteria, Puccinia, Agaricus, and Equisetum have been added and the forms discussed in the older book receive more attention. A brief chapter (Chapter XII) on the ecology of leaves, with a statement of

the ecological classes of plants in their relations to the needed supply of water, has been inserted. A statement of the general characteristics of cryptogams and a few notes on the evolutionary history of plants constitute the closing chapter."

This passage indicates that there was dissatisfaction among teaching botanists, and that the disciplinary value of systematic morphological botany was being challenged. The inclusion of plant physiology as an integral part of the high school course in botany shows that the teachers recognized for the first time the need for the inclusion of physiological processes and the relation of life processes to environment. The movement toward plant ecology, plant physiology, and economic relations was under way.

Suydam in "High School Botany" *(School Science and Mathematics*, February-March, 1903) writes:

"What the high school pupil needs in the way of knowledge and discipline to be of any practical value to him is knowledge and discipline which will enable him to recognize the various trees, shrubs, and herbs in his locality and to know of their value or harm to mankind; knowledge which will tell him of the habits of these plants, where they live, how they live, what conditions are beneficial and what are not; knowledge relating to the economic value of plants, what plants are of economic value, how they grow and where they grow best, what soils they are best suited to, what their enemies are and how these enemies are recognized by man and subdued."

This attitude represents the point of view for the decade from 1900 to 1910.

It is needless to cite illustrations of the same points of view in the zoological and physiological text books, paralleling those in botany, as the same trends were apparent there also. The courses in all three biological sciences were at first half-year courses, but gradually some of the high schools replaced the half-year courses by so-called "biology" courses which at first were little more than uncoordinated courses in elementary botany, zoology, and human physiology. The pragmatism of the decade reflected itself in the interest evinced by the public in what was being taught in the high school.

The *Report of the Commission on the Reorganization of Science in Secondary Schools* issued in 1920 (Bulletin 1920, No. 26, p. 29), states under the heading "Changes in the point of view of biological teaching":

"When biology was introduced into the secondary school, the subject was taught by men and women trained almost wholly in college courses in morphology and classification; and in consequence a diluted type of college course was almost inevitable in the high school. Much of the laboratory material consisted of preserved specimens of plants and animals. Microscopical work of too difficult a type was insisted upon. Herbaria of dried specimens cluttered home and school.

In recent years increasing emphasis has been placed on the study of living organisms. Physiological experiments and ecological studies have been introduced. But still the type of topic selected for study is more or less that which appeals to the adult mind rather than to the mind of the adolescent. The material used was often remote from the every day experience of the students, and biological studies still failed to function as largely as had been hoped.

When teachers began to present biology in its relation to human welfare, a new and vital interest in the subject was awakened, and in many schools biology has become deservedly popular. It is evident that further progress in the pedagogy of the subject should be made along the line of organization of courses in biology which relate to various aspects of human welfare."

PERIOD OF CORRELATION AND APPLICATION OF BIOLOGY

It is generally conceded that the first course in elementary biology in this country seems to have been prepared by the Regents of New York State in 1899.

George William Hunter, a pioneer in the attempt to weld the three disjointed courses into a unified whole, and the teacher who was the first to attempt to organize a text to follow the syllabus, writes in the Preface of his *Elements of Biology* (American Book Co., 1907), page 5:

"The aim of this book is to correlate the allied subjects of botany, zoology, and human physiology in a general course of biology for the first year of the high school. The foundation principles upon which this correlation is made are that the life processes of plants and of animals are similar, and in many respects, identical; that the properties and activities of protoplasm are the same whether in the cell of a plant or of an animal; and that the human body is a delicate machine built out of that same mysterious living matter, protoplasm. With such a foundation correlation is not only possible, but natural.

The following pages are the results of my experience with large classes of young students in the first year of the high school. The average age of such pupils is about fourteen years. To such pupils the life activities of plants and animals have an appealing interest; simple experiments in plant physiology are performed with never failing zest. Laboratory and field work, so far as they relate to adaptations to functions, are readily comprehended."

To Be Continued.

A Science Project

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An oil well that really works, built by Eugene Bosle, a student at Saint Michael's High School, Pittsburgh.

Science at the High School Level

● By Rev. John F. Hammond, O.S.A., Ph.D., *(University of Chicago)*
DEPARTMENT OF CHEMISTRY, VILLANOVA COLLEGE

Adapted from a paper read at an Augustinian Educational Convention held in Washington in December, 1934, this article reflects the experience of one who has spent a number of years in the high school science field and understands its problems.

Father Hammond discusses teacher preparation, the science library, and teaching aids, but his article is written chiefly to suggest a desirable four-year science curriculum, one which is fitted to the needs of high school students. This new curriculum has dependent continuity. It avoids unnecessary repetition.

We suggest the careful study of this well-considered plan by superintendents of schools, high school principals, and others responsible for the character of the science instruction in our high schools.

●

At the present time the expression "high-school science" in its generally accepted meaning, includes the biological and physical sciences, whether they be offered as survey courses, such as General Science, or as courses in specific subjects, such as Chemistry.

The object of the present paper is to offer what may be considered a desirable curriculum in science at the high-school level and to discuss ways and means of improving science instruction in our Catholic high schools.

At the outset it will be well to keep in mind the following facts:

(1) That most of the high schools in the large cities under diocesan jurisdiction, or under the jurisdiction of the teaching orders, are regular four-year high schools for boys only or for girls only, with an average enrollment of one hundred to two hundred (few exceeding four hundred). In the smaller communities both boys and girls attend the same high school.

(2) That nearly all of these schools are day* schools with a scholastic year of thirty-six to thirty-eight weeks.

(3) That pupils for the most part come from parochial schools with little or no previous training in science.

(4) That the schools are located in widely different parts of the country and are governed by different accrediting agencies and educational associations.

(5) That for the greater number of boys or girls attending our high schools, high school is a finishing school; for the smaller number, say 20 per cent, it is college preparatory.

(6) That some of the schools are exclusively devoted to the training of the youth for membership in a religious order (or for the priesthood) and some are called "select"; and that, for purposes of science instruction, there should be no great difference between the science courses offered in these schools and the science taught in the other schools (except, perhaps, that science courses offered in these should be more on the style of college preparatory).

*In contradistinction to evening schools.

It is also worthy of note that, in so far as science is concerned, the urgent need in the high schools is that of teacher preparation. It seems there already exist a fairly well organized science curriculum and standard laboratory equipment in most of the schools. General Science is being taught in first year; one of the biological sciences, in second year; Physics and Chemistry, in third and fourth years; and, quite recently, most of the schools have installed science laboratories that are at least moderately well equipped.

Next to the need of properly trained science instructors one may place that of a science library. Accrediting agencies are insisting upon the necessity of an adequate science library as a most essential aid in science instruction.

In the way of supplying these two present existing needs it is proposed, after the discussion of the science curriculum, to offer a plan for the training of the high school science teacher and to recommend lists of selected science books that should be on the shelves of the high school library. As a fourth topic, if space permits, "other aids" for the improvement of science instruction may be discussed.

Science Curriculum

In recent years many very excellent studies in the reorganization of the high-school science curriculum have been made. In the eastern section of the country the New York State Regents are recognized as having attained a rather high standard. In the mid-western section the North Central Association took up the work of high-school curriculum reorganization and published the results in book form in 1933.[1] Four years ago the National Society for the Study of Education published a program for teaching science both at the high-school level and in the elementary grades.[2] An outstanding contribution on science instruction by W. L. Beauchamp may be found in the monograph written under the direction of the Office of Education in Washington, D.C., which undertook within the last few years to make a national survey of secondary education.[3] Many of the state universities have made special studies in the way of science curriculum-making. Collectively these studies represent the earnest efforts of specialists well trained and experienced in curriculum-making and in the fields of special sciences. They represent the expenditure of thousands of dollars required by investigations, clerical work, and other expenses attendant upon such activities.

One may not always adopt the same philosophy of education that is proposed by these educators, nor be governed at all times by the same general goals and

specific objectives recommended by them. But, in the main, these contributions, in addition to indicating the trends in high school science instruction, are very helpful guide posts in formulating the units of the science courses in our secondary schools.

In offering a sequence in science subjects suitable for high school students it is desirable that the courses should be designed to acquaint the pupils in an elementary way with the more important forces and laws of nature. Furthermore, the science curriculum should be so constructed as to give pupils an understanding and appreciation of these laws and forces as they influence every-day life. To quote from Downing,[1] "science as a part of a general education should be so taught that it will enable the average individual to apply it to the solution of those problems involving science which will arise in his life—not only those problems which demand solution because he must do something about them, but also those he attempts to solve merely to satisfy his intellectual curiosity. This average individual needs what may be designated *consumer science* as distinct from *producer science* the science of the specialist or the research student." Our problem then in the teaching of high school science is not so much that of training boys and girls to become scientists, as it is that of helping them to become intelligent laymen. Emphasis should be placed upon the understanding of principles rather than upon the accumulation of details and facts. One is lost in the maze of factual material presented in textbooks of science; and, *unless the generalizations of science are stressed*, one cannot hope to obtain the mastery of those principles which form the basis for the interpretation of biological and physical phenomena. In all courses, systematic methods should be emphasized and scientific attitudes should be developed;[2] and pupils should be trained in drawing proper conclusions from established facts and principles.

At the present time the most widespread plan of offering science at the high school level is to provide a course for each year, calling the courses, if you will, Science I, II, III, and IV. It is the aim to plan these courses in such manner that there will be dependent continuity throughout the four grades and there will be no useless repetition of units that have been previously mastered. Science I and II should be required of all pupils; Science III and IV may be made elective. On the assumption that the first two courses carry with them full units of credit, the requirement of the educational associations (that each prospective graduate present two units in science) is fulfilled. Moreover, as was previously mentioned, high school for 80 per cent of the pupils that go there is a finishing school, and many (say 30%) are compelled to withdraw at the end of the second year. It is certainly very desirable that these boys and girls should be acquainted with the common materials and facts in nature and should be given an understanding of these materials and facts as they influence human life. Materials out of which the earth is made; facts of the universe in general; the motion of the planets; the earth in its relationship to other bodies of the universe; the life, both plant and animal, that exists on the earth; food required to sustain life, both plant and animal; man's relation to the other beings on the earth; problems of hygiene, of clothing, of communication and of transportation—these may well be put in courses, Science I and II (more frequently called General Science and General Biology) offered in the first two years of high school. In the selection of textbooks for these courses the author has found it best to use those that treat of the fundamentals of natural science as an integrated two-year science program organized in terms of *units of understanding*.

In any course in science not more than eight or nine units should be taken up in the period of thirty-six weeks—a normal school year. There is included in this paper an outline of the course in terms of units; but, in general, it is recommended that it be left to the judgment and experience of the teacher just what units are calculated to lay the basis for the solution of the problems pupils in high schools in the different sections of the country must solve. The teacher will be guided by the vocations and avocations of the people in the particular section; by the knowledge necessary to read intelligently articles that appear in current periodicals and newspapers; by the interests displayed by pupils in the natural science fields. Nevertheless, whatever the calling in life or the particular interests of the pupils, the science offered in the first two years of high school should impart the principles by which the pupil may be enabled to solve problems of every-day life that are more or less common to all of us.

It is suggested that Science III and IV be elective and that, in accordance with general practice, they be Physics and Chemistry, respectively; or, as an alternative, that a course be offered in *fundamentals of physical science* and that such a course offer units on the nature of matter, the concept of energy, heat and temperature, transformations of matter, electricity, etc. In schools that have an enrollment of not more than two hundred such a course (fundamentals of physical science) is recommended for third and fourth year students combined. Or it may be better to offer one year a course in physics to third and fourth year students combined, and the next year a course in chemistry to third and fourth year students combined. Of the two subjects physics is more desirable in high school than chemistry. It is well to note here that the same plan would obtain for girls' high schools as for boys' with the possible exception of Science III (Physics), the units of which may be offered better in the reverse order stressing more sound and light than electricity and mechanics for them. At the present time it is not customary to offer courses in the specialized fields of science more than these suggested, unless the school has an enrollment of one thousand or more.

It may be well to say a word or two about the organization and method of the courses. The science courses are organized in terms of units, each of which

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The Effect of Temperature in
The Preserving of Food . . .

• By Margaret Smith
LOURDES ACADEMY, CLEVELAND

This essay won first honors in a contest for high school students conducted in connection with the fourth annual Conference for Teachers of Science in the Catholic High Schools recently held at Duquesne University. Some 40 schools were represented in the contest.

Honorable mention was given to Jeanne Semark, Villa Maria High School, Wickliffe, Ohio, conducted by the Sisters of the Holy Humility of Mary; to Jeanne Richardson, Annunciation High School, Pittsburgh, conducted by the Sisters of St. Joseph; and to Jeanne Ryan of Saint Rosalia High School, Pittsburgh, conducted by the Sisters of the Immaculate Heart of Mary

The need for the preservation of foods is evident even to those unversed in bacteriology, for, as every housewife knows, after foods which easily spoil are left in the heat a certain length of time, an obnoxious odor and repugnant taste make the food undesirable. To those who understand the harm wrought in foods by tiny microörganisms, such as molds, bacteria, and yeasts, the need for the preservation of foods is doubly evident. In view of these facts the question of how foods may be preserved arises. In olden days, as in our modern age, temperatures, both high and low, proved to be the most efficient means of combating the spoilage of food; hence, the discussion of temperature as a preservative of foods is an important and interesting topic.

Since this subject is extensive, to divide the exposition of the matter into sections will add to the clarity and simplicity of treatment. Therefore, an attempt to describe the relative effects of different temperatures upon edibles will be made in the following paragraphs, entitled respectively:

The Origin of Refrigeration and the Effect of Cold upon Foods,
The History of Heat and the Manner in Which Heat Affects Foods,
The Comparison of the Effects of Heat and Cold upon Foods.

The history of refrigeration brings to mind such eminent men as Marco Polo, Sir Walter Scott and Lord Francis Bacon. Both Marco Polo and Sir Walter Scott contributed to the science of refrigeration by relating instances of this method of food preservation in the Far East. Lord Bacon valiantly gave his life for this science when he stepped from his carriage on a cold winter day and, after stuffing a chicken with snow, attempted to demonstrate his theory of refrigeration. As a result of this experiment, he contracted pneumonia and never recovered. These interesting attempts were only the beginnings of refrigeration. Later Faraday, Dr. Cullen, Dr. Gorrie, David Boyle and a host of others aided in perfecting cold storage.

MARGARET SMITH

Miss Smith, sixteen, has led her classes during the past two years. She has studied general science and biology. Sister Mary Ida of the Holy Humility of Mary Order is her science teacher.

Many of the foods that we enjoy the year round, such as grapefruit, lettuce, and tomatoes would be obtainable for only a part of the year if it were not for refrigeration. However, because of our modern means of preserving foods, these delectable products remain with us for the entire year to gratify the palate.

Economy also enters into the question. We may thank cold storage for the low price at which foods may be purchased. Because fruits are less likely to decay during shipment in refrigerator cars, large quantities of these perishable foods can be shipped great distances.

Refrigeration is widely used in commerce and in homes as a satisfactory means of storing food. Whereas such semi-perishable foods as potatoes, apples, turnips, carrots, and onions can be stored in cellars and still remain safe from deterioration, perishable foods such as fresh milk, meat, and butter must be kept in a colder place. In this instance, refrigeration figures greatly. Though it is a more expensive process than cellar storage, it is more efficient, inasmuch as perishable foods are best kept just above the freezing point.

In the development of refrigeration we recalled the names of eminent men of the past; so in the origin of the heating process of preserving, we come upon a great name of the eighteenth century. There is this difference, however, that the man with whom we are now concerned does not figure directly in the development of heat preservation. We speak of Napoleon Bonaparte, one of the greatest military geniuses the world has

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Education as a Science . . .

• By A. John Goetz, Ph.D.
PROFESSOR OF EDUCATION, DUQUESNE UNIVERSITY

This thought-provoking article deals with the results and the possibilities of the application of science and the scientific principle in education.

"Education viewed scientifically has a profound effect on educational progress. No teacher can claim title to progressivism unless she familiarizes herself with the system, methods, devices and aids which are the gifts of Science."

Dr. Goetz's discussion of this topic was one of the features of the recent Duquesne University Conference for Teachers of Science in the Catholic High Schools.

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Through the centuries variant views of education have been propounded by philosophers, educators, and laymen. The cause of the variance lies in non-recognition of the concept of man as found in the Bible: God's explanation of His creative Idea. It is age-old experience that the further philosophy departs from revealed doctrine, the more groping become its processes, and the more inconsistent its conclusions. The point of convergence in ontological speculation is the *will* to acknowledge man as an un-evolved creature, fashioned by the Creator, "according to His own Image and Likeness." Some philosophers, albeit pagan, such as Socrates, Plato and Aristotle did understand through reason and will that man combines the physical and metaphysical, the corporeal and the spiritual—body and soul—and is endowed by the Supreme Intelligent Creator of the universe, with life, mortality and immortality. This conclusion transcends the realms of opinion, theory and hypothesis, and establishes a motive for man's education that is essential, intrinsic and invariable.

To attempt to define education categorically without admitting this concept of man, would be as impossible a task as to define civilization without considering ethnological factors. To transplant a savage from the heart of Australia to the heart of New York City would stun him into insensibility by the intensity of the insensate lives of the white natives. To condemn the uncivilized custom of exposing Spartan infants on mountainsides, the while, we, in this civilized twentieth century prescribe sterilization by law, and clamor for liberalization of contra-natural race-suicidal practices, would be like the kettle calling the pot black! The only absolute criterion of civilization, as of education, is found in the following of Christ.

For the sake of clarity, and as a logical preamble to our discussion of education as a science, let me re-affirm the principles of Christian philosophy that must constitute the basis for any true definition of education.

1. Man is a rational animal composed of body and soul, created by God for time and eternity.
2. He is endowed by his Creator with physical and spiritual faculties which must be cultivated unto perfection. "Education means the giving to the body and the soul all the perfections of which they are susceptible," is the definition of Plato.
3. The perfecting of his faculties must be in accordance with precept and reason: precept for the proper direction of his powers; reason for the proper ordination of his conduct.
4. The direction of his powers is the specific function of the social agencies of education, namely, the home, the Church, the State, the schools, and books.
5. The ordination of his conduct is the responsibility of the individual himself. "The true aim of education," says Aristotle, "is the attainment of happiness through perfect virtue."
6. These acts of directing, ordaining and perfecting are human processes which demand for their consummation a conscious, deliberately worked-out system: "Education is a natural, progressive, systematic development of all the powers" is the view of Pestalozzi.
7. Method and system are as indispensable to art as they are to science—"Art and science have their meeting point in method"—Bulwer. Method is the basic element in discipline, and discipline is the end and objective of education. This fundamental principle must satisfy those traditionalists who insist that education is an art. We concede that, as a subjective evolution, education is an art; as an objective adjustment, education is a science.

"The true object of education should be to train one to think clearly and act rightly"—Van Dyke. With the admission of a basic educational philosophy that comprehends the scientific we are prepared to enlarge our thesis that education may be viewed as a science.

Science is a method of determining facts, or of predicting a sequence of events. It is a statement of truths found out, the embodiment of organized common sense; it is careful quantitative recording, not speculation or supposition.

Aristotle classed sciences as (1) theoretical, (2) practical, (3) poetical. In a general way the theoretical sciences are those in which discoveries are made; the practical sciences represent the branches which

teach how to apply knowledge for the benefit of mankind; the poetical sciences embody the creative and technical arts.

It was precisely the Greeks who first worked out a theory and practice of education based upon scientific principles. The great end of education for them as well as for the medieval scholastics and early modern educators, was to discipline rather than to furnish the mind.

In our age, the study of education is generally looked upon as a science in that it has a body of data quite as definite as that of many of the applied sciences, and has well-defined methods of dealing with such data. It is not a science in the sense of having any universally accepted group of principles as a basis of study, and in this, it is in the same status as history, sociology, political science and economics. As an applied science education recognizes the coordinate value of method and subject matter; it employs tested processes in the development of the faculties, and emphasizes the relation of educational activities to society; it aims at scientific exposition and scientific formulation of the principles of method and curriculum in their mutual relations. Arguing from these premises, yet allowing for traditional conservatism, let us demonstrate the positive educational value of the scientific view. Since the great experiment of Pestalozzi at Yverdon there has been evidence of universal faith in pedagogical experimentation patterned after the inductive method promulgated by Francis Bacon. Not a rash, uncalculating experimentation, but an accurate, fact-finding procedure, typical of scientific minds. Educational novelties have always been discouraged and fantastic innovations condemned by wise leaders. The flare for intelligence testing, for example, which gained such popularity after the findings of Binet and Simon in France a half century ago, has long since yielded to sane and practical methods of objective measurement.

The use of the scientific method in evaluating educational processes led to a renewed interest in psychology in teaching. "The method of teaching which approaches most nearly to the method of investigation is incomparably the best; since not content with serving up a few barren and lifeless truths, it leads to the stalk on which they grow," wrote Burke. There can be no accuracy of action unless facts are observed, checked, and compared in the same way that the scientist investigates, experiments and verifies in his laboratory work. The untrained observer usually makes too few observations, fails to record them, neglects to weigh the conditions under which they were made and overlooks the events which follow.

Educational history is crowded with superstitions which held sway so long as there was no corrective to dispel them. For example, it was generally assumed that reasoning in some narrow field or subject would equally improve one's ability to reason in all fields. That has been exploded, just as the superstitions about black cats and walking under ladders. There is law in the physical world and law in the psychological world. With the advent of educational psychology the scientific attitude became firmly entrenched. This study attempts to determine why pupils act as they do. While we do not determine absolutely, yet in the thirty years of using the scientific approach we have made marvelous advances. Years ago, long drill periods were the accepted method of impressing knowledge. In the light of patient investigation we now know that short drills at more frequent intervals is a much superior practice. Predicting what a child may accomplish is very common today. A boy tested at the age of 6 years, 11 months was found to have the intelligence of a 10 year old. It was predicted that he would enter High School at 11. He entered at 10 years and 5 months. We do not pretend absolute accuracy in these predictions, because an intelligence test is no infallible indication of what one will accomplish, because frequently, a child may have mental ability and not make use of it.

In science, one of the most effective observational methods is that of "experimental control," or experiment and deduction by comparison. The research scientist, for instance, wishes to determine the efficacy of a vaccine which he has produced. He may select 200 persons and innoculate every alternate one, or he may use an experimental group of 100 (vaccinated) and a control group of 100 (unvaccinated). Conditions and circumstances being equal and constant, the results will be relatively conclusive. The scientist knows that the larger the group, the less possibility there is for miscalculations arising from chance factors. Recall the illustrious Louis Pasteur in his experiments with anthrax vaccine. His greatest difficulty was to secure the animals for his tests. Despite the scepticism of the intellectuals, who, by the way, should have been the very ones to abet his research work, he was finally successful in obtaining 50 sheep from the Society of Agriculture of Melun. 25 sheep were innoculated and 25 were not. You know the humanitarian results of that classic example of experimental control.

In imitation of this scientific method of countercheck, educational psychology has been able to formulate rules and relative laws which have proved invaluable to progressive teachers. Permit me to enumerate, without comment, a few of the most practicable and universally acknowledged laws of learning: The law of readiness or mental responsiveness; the law of exercise (use, disuse, distribution of practice); the law of effect (the aid of satisfaction in learning and the handicap of annoyance); the law of association which has engendered widespread enthusiasm for the use of visual aids and projects; the socialized recitation (the group interest medium). The scientific attitude has brought into being a Methodology which squares in every detail with the traditional rules of scholastic philosophy. For example: educability differs with each child and at each period in his life; the modification through education of physical and mental conditions affected by environment; a strong tendency toward a

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The Problem of Supervised Study

• By Mary W. Muldoon
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SUMMER FACULTY, OSWEGO NORMAL SCHOOL

The practical discussion of directed study which was begun in our March number is here continued. It will challenge your thought.

Miss Muldoon's ideas concerning completely individualized instruction, group drills, motivation, assigning the lesson, use of the textbook, written work, testing, and other practical problems of the classroom teacher will interest you.

Again, supervised study works!

PART II.

As stated in an earlier article, the writer's experience indicates that there are at least three separate training levels in teaching students to use textbooks efficiently. The first is being able to find in any particular paragraph the answer to a definite question. The second is being able to locate in the text by means of a furnished outline the important items which must be learned or mastered. The third, which many students of low I. Q. will never be able to reach, is being able to make independently an outline, or précis, or summary of the material assigned for study.

No matter how long it may take us to accomplish the first step—we had one seventh grade class this year that used twenty-seven weeks to reach the second level—the day eventually comes when we can say, even to the "slow progress" group, "Up to today we have been using questions to help you in studying your lessons. Now we think you are ready for a more-grown-up method, and after this we shall give you outlines instead of questions. The outline for your next assignment is on the board. It really is an abbreviated way of asking questions. I am going to show you how to use it."

Objection immediately arises: "In his English class this pupil has made outlines for compositions, and has written articles from these outlines. How is this different? Why is additional training necessary?"

Yes, the student has been trained to build outlines for original paragraphs. Now we are asking him to find out what a trained scientist with an extensive vocabulary, and only too often a very technical one, means in several pages of unfamiliar text. From his fourteen-year-old viewpoint this is an entirely different proposition from organizing material with which he is perfectly familiar, and in which the relative importance of items is clear in his own mind. With his new science text—unquestionably the most difficult reading he has yet been asked to undertake—he is at a loss to determine which part he is simply to read, and which part he must learn; which items are of passing interest merely, and which must be permanently mastered.

He must at once be taught a new kind of "skimming," to help him in reading more rapidly, and he should be assisted in determining the relative importance of the items, this being the purpose of his outline. If he studies in the same classroom, the outline may be on the board in front, where he can copy it or not as he considers necessary. If he studies elsewhere, mimeographed or some other kind of duplicated outlines should be passed out. No student time should be wasted in compulsory copying, or in writing outlines from dictation. There are various other advantages attached to these duplicated assignments, which may cover the work for a day, a week, or a complete unit as the instructor pleases, though for the sake of the high I. Q. group of "rapid progress" students, one of the latter is recommended.

SAMPLE BOARD OUTLINE
(Assignment for One Day)

Applications of Air Pressure

I. Siphon:

a. appearance
b. operating conditions
c. direction of flow
d. reason for flow
e. limit of lifting power
f. industrial uses
g. definition
h. sketch apparatus on table for notebook — use full page; label

Vocabulary List

1. vacuum
2. partial vacuum
3. normal pressure
4. increased pressure
5. decreased pressure
6. valve
7. plunger
8. siphon
9. lift pump
10. operating conditions
11. industrial uses

II. Locate:

(1) partial vacuum and
(2) surface acted upon by air pressure in each of the following:

(a) drinking from cup through straw
(b) filling fountain pen
(c) filling medicine dropper
(d) using vacuum cleaner
(e) using lift pump

It is taken for granted that before this assignment is made the student knows by means of experiment and demonstration, observation and previous study, that air has weight and exerts pressure, and that he also knows the difference between perfect and partial vacuum. He understands that the vocabulary list is to be copied into the "Vocabulary Section" of his science notebook, and that he is to learn to spell and pronounce each word or phrase, and be able to use each correctly in a sensi-

ble sentence. It is likewise to be understood that during the earlier part of the class meeting his teacher has made or shown a glass siphon, demonstrated its working, and motivated the study period by saying, "I've shown you *how* a siphon works. Your text will explain *why* it works." This has also been done for the lift pump.

The inexperienced beginner must note carefully the first difference in procedure on the second level: *The student must skim the entire text description of his topic before he is ready to study.* He is now shown that there are two steps to this skimming: first by use of heavy-type paragraph topics he locates the sections referring to siphons; then, by glancing rapidly down the middle section of the page, he finds the part in which he is directly interested. Some students find it easier to get a general idea of the context by reading the first and last sentence and sometimes one other sentence approximately in the middle of each paragraph.

Now let us go back to the lesson on that outline, which will probably go something like this:

"In a few minutes I'm going to ask you to study about the siphon, but first I'm going to be sure that you understand what the outline asks of you. That first item, item "a," really means, 'Describe a siphon's appearance' or 'Tell what a siphon looks like.' How will you find out?"

"Study the pictures"—"Look at the siphons on the table."

"'Operating conditions'—this means 'Under what circumstances will the siphon work?' It doesn't work everywhere, as your book will tell you. The text does tell where it will work, and why."

"'Direction of flow' means will the liquid flow toward the short arm or toward the long one, and will it always flow in the same direction? You should know this after watching our siphon, but if you have forgotten, or if you overlooked it, the text will tell you the answer."

"'Limit of lifting power,' means what is the greatest height to which the siphon will lift the liquid, and why? 'Four industrial uses,' means four uses in business. Now, I'm going to give you a few minutes to read. After you are more familiar with the material, we'll discuss these items again."

As soon as the instructor sees that two or three of the quicker students are ready "Time" is called, followed by the question:

"What does the first item mean, Tom?"

"Tell what a siphon looks like."

"Read us the answer, but first tell us where to find it in the text."

"In the first paragraph—'A U-shaped tube.'"

"Do you agree, Charles?"

"I think it should be, 'A U-shaped tube with one arm longer than the other.'"

"So do I. What is the meaning of operating conditions, William?"

"The conditions you have to have before your siphon will work."

"Tell us where you find it in the text, and then read us those conditions."

"In the first paragraph," and he reads them.

"What does the next item mean, Albert?"

"Does the liquid flow toward the long arm or toward the short arm, and why."

"Read the parts of the lesson that tell you," and so on down to "define siphon" where a new problem of technique arises—Shall we dictate a definition to be learned by the class, or help them to build one which they will understand? The writer believes in the latter method and uses the same skeleton for building definitions that is used by the ninth grade in writing a brief news item—"Tell who does what; when; where; and usually how or why."

"What is a siphon? You know it isn't a stone wall. How could you tell it from a stone wall?—*In one word*, what is it?"

"A tube." "A U-shaped tube."

"That is right. Now a tube which does what?"

"It transfers liquids from one container to another."

"When or where?"

"Where the difference in level is not over 34 feet."

"Why?"

"Because of the air pressure on the surface of the water in one container."—"Because of the difference in the weight of the columns of liquid in the two arms."

As the discussion proceeds, the teacher jots down the items as they are mentioned, and now has an outline on the board looking probably something like this:

Siphon:
U-shaped tube
transfers liquids
difference in level
pressure on surface and
weight of arms

"Both right. Now look at our notes on the board, and build a smoothly worded definition."

We teach practically all of our definitions in this fashion. Sometimes we do not need every item in our skeletonized outline, but we always tell "who does what" and examine the other items to see if anything more needs to be included. Suppose we are defining photosynthesis. "It isn't a stone wall. *In one word*, what is it?"

"Process."

"Which does what?"

"Manufactures starch (or sugar)."

"Where?"

"In green leaves."

"When?"

"During sunlight."

Now we can safely dictate that smoothed definition, though the writer does not advocate it. The direction that might better be given is not, "Be sure to remember this," but "Don't try to *remember* this. If you *understand* this thing you can always build a good definition by yourself."

Please note that up to this point in the work we have simply been calling the student's attention to the *new* things in the assignment—the things that he doesn't know and must learn. *Now we must give him the*

chance to learn them, so we close this portion of the lesson saying, "We have shown you where to find all the facts. How will you know when you have learned your lesson? How will you know when your studying is complete?"

"When you can explain all your diagrams."—"When you can shut your book and cover up your reference material."—"When you can recite to yourself without any help."—"When you can explain it to someone else so they can understand it."

"Suppose you find that you can't do this the first time you try?"

"Then you need to study it some more."—"You need to study it again until you can."

When we begin to test the described assignment tomorrow there are many optional methods. We may ask one pupil to stand and talk, without interruption, to the class from the outline on the board, the other students having the privilege of asking him questions when he finishes. He may be stopped at any point for another to take up the tale. There may be as many students at the board as can be accommodated, each to write out some item of Section II in the sample outline. These will be criticized and marked as usual. There may be a series of rapid outline sketches, pen, medicine dropper, etc., which have been placed on the board before the class by some of the quicker students, each sketch to be explained to the class by another pupil; or we may have a "one word" fact test, similar to the one previously described.

Examination of the above procedure will show that the only difference between what is usually known to high school pupils as a "class" or a "recitation," and the first part of the directed study period, is that in the first the students are discussing with the teacher—or "reciting"—material with which they have familiarized themselves by study, and about which they are supposed to have formed conclusions; in the second, the instructor by means of experiment, demonstration, or Socratic questioning is helping the student with his opened book to come to conclusions about new material. In any class using the methods recommended, there is no hard and fast line between recitation, discussion, and supervised or directed study, except that the first few minutes of the class hour are usually devoted to testing the preparation of the last assignment. The rest of the time is devoted to actual teaching, the first contact with the advance lesson being made through the teacher, *who by his development, through experiment, demonstration, or Socratic questioning, motivates the use of the text during the pupil's period for independent study.* The study of the text simply reinforces the teacher's development of the new problem.

The entire period may be devoted to directed study on some days, while on other days no time may be allotted for it at all. For example, in the class whose work we have been following, Monday probably was a laboratory period, during which several demonstrations of the weight and pressure of air, and the students' notes for their reports used all the time; no text assignment was made. On Tuesday, a five-minute discussion of yesterday's demonstration was followed by a demonstration of the principle of the mercury barometer. This, with accompanying discussion, took about fifteen minutes. There was a text assignment upon the barometer, aneroid barometer, barograph, and the two main kinds of aircraft. The instructor helped with the text during the first part of the remaining time, and the pupils studied independently during the rest of the period. Wednesday saw a five-minute discussion of aircraft, followed by a demonstration of the lift pump and the siphon, with about ten minutes of directed study, followed by independent study. Thursday will probably see half of the period used by board work on power questions involving any of the assignments made during the week, with half of the remainder devoted to helping with the text description of compressed air and its commercial applications, the rest to independent study. Friday will probably bring a check-up test upon the week's work—ten dictated completion questions, ten true or false, and one essay-type, power question which will be placed on the board. The test will be timed, and followed by a laboratory demonstration of the approximate volume of O in the air, and the presence of CO_2 in air and in exhaled breath, which may use the entire period. In such case there will be no help with the text, the assignment being writing up the report, and reading the text explanation of the demonstrations. The time spent in study will, of course, vary from day to day, but it will take approximately half of the class time from week to week.

As the student gradually grows in his understanding of the use of his outline, the teacher gives less and less assistance with the text, until finally all that is necessary in the normal class is the brief daily discussion of particularly obscure or difficult points. The usual class hour program will then run somewhat as follows: (1) "Are there any questions which you now cannot answer about the assignment?" These are cleared up by reference to open texts if possible; if not, by the teacher's explanation. (2) Brief and rapid testing of the previous assignment, either through board work, "one-word fact test," or oral discussion by individual students following the outline. (3) Development of the advanced assignment by the instructor, including as much assistance with the text as is necessary to insure successful study by the group. (4) Independent study for a part of the period by the group, leaving the instructor free to observe study methods, to work with absentees or with students slower than the average, or to make constructive suggestions as he passes around the class.

When the majority of the class is able to begin independent study, there are always one or two slow or puzzled students who "can't see it." They may be taken for individual assistance at the desk, or better at the rear board, where they do not disturb the others. The stronger students may occasionally assist with this, especially in the case of absentees. Even with these slow students, independent study during part of the period is an essential. We are attempting to build the

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You Should Read

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Through the Telescope

●*By* EDWARD ARTHUR FATH, Professor of Astronomy, Carleton College. Whittlesey House. McGraw-Hill Book Company, Inc. New York, 1935, vii + 220. $2.75. Illustrated.

This book is easy reading. Its descriptions are always clear and often striking. In fact, the teacher of rhetoric might well open the book at random and use the text to illustrate some of the finer qualities of style. *Through the Telescope* is meant for the average non-scientific reader.

Imagination is constantly used to bring home the most important facts of astronomy. And yet, as far as it goes, this book is strictly scientific. Details of calculation are, of course, avoided, but the more imortant results are clearly stated. To the general reader the book can be recommended without reserve. To the student who wishes later to take a course in descriptive or mathematical astronomy we particularly commend the first part of this book. He will not readily find a clearer description of the solar system in so brief a compass.

Patrick Cronin, Ph.D.,
Duquesne University.

Handbook of the Heavens

●*Edited by* HUBERT J. BERNHARD, DOROTHY A. BENNETT and HUGH S. RICE. Whittlesey House. McGraw-Hill Book Company, Inc., 1935. 131. $1.00.

Highlights of Astronomy

●*By* WALTER BARTKY, Associate Professor of Astronomy, The University of Chicago. University of Chicago Press, 1935. xiii + 280. $2.50.

Here are two works on astronomy for the non-professional lover of the stars. Neither one is to be used as a textbook for the student, but they are both designed to give the beginner a general educational background before he ventures out into the deeper reaches of the science.

The *Handbook of the Heavens* is a small volume, unique in its makeup, as it is written by the members of the Junior Astronomy Club at the American Museum of Natural History, a group of young people who have made astronomy their hobby. They know exactly what is needed to awaken an interest in the study of the heavens and, without going into details or calculations, they give in their book an introduction to their hobby. They tell where to find and how to identify the constellations, nebulas, double stars and other interesting objects that can be seen through small telescopes or field glasses, and give enough information in plain language to start other young people on exploring trips in the sky.

A different kind of work is Bartky's *Highlights of Astronomy*. Here the more mature reader will find an introduction to the science which will serve as a foundation for more extended study. The book is delightfully written and highly interesting even for the general reader who has no intention of becoming an astronomer. We are taken from the earth and placed on the rotating ball, freely suspended in space and moving with enormous speed around the sun. The laws which govern the movements of our solar system are explained in simple language and by experiments and examples which are easily grasped. Excellent charts are scattered through the pages, to help the reader in locating the planets at any time in the sky. Speculations and theories are generally omitted.

There is also an ingenious instrument recommended, the *Stellarscope*, with which one can see various constellations on a moving picture film which is to be superimposed upon that portion of the sky where the sought-for constellation is located. This is only a toy, and of doubtful value. The price including a film with 24 star maps, is $2.00.

Dr. M. W. Kurniker,
Author, The Cosmic Cycle.

Bird Portraits in Color

●*By* THOMAS S. ROBERTS, Professor of Ornithology and Director of the Museum of Natural History, University of Minnesota; University of Minnesota Press, Minneapolis, 1935. 90 plates + vi. $3.50. Index.

Bird Portraits in Color is a splendid portrayal of the beauty of birds. The colored pictures of the many birds which it presents are so natural that the birds may be easily recognized at sight. The observer will be able to distinguish one bird from others of the same family. The interesting descriptions which accompany the "portraits" give just the information needed not only by a beginner but also by the student of bird life and the bird lover generally. They treat of the uses, songs, habits, home life, nestings, haunts and migrations of a great many birds. Arranging them by families, haunts and climatic locations, the author studies water and land birds, birds of the deep forest and prairie, and birds of the field, meadow, garden, yard, orchard and marshes. He discusses their cooperation with man in making the world a better place in which to live. This beautiful book is a great find for those beginning the study of birds.

Intimate sketches are given of the destructive English sparrow, the starling, the rose-breasted grosbeak in the potato patch, the purple martin as a fly catcher, the Baltimore oriole, the tiny humming bird in its miniature nest of cobwebs, the kingfisher with its nestlings deep underground, the golden plover, the coveys of bobwhite, the bluebird most beneficial to the farmer, the whiskey jack nesting in zero weather, the woodpecker as savior of the forest, and scores of other interesting birds. Bird music is described in stories of the beautiful songs of the thrush, the warbler, the meadow lark and the mocking bird.

This searching treatment of bird life would be a valuable contribution to any library, public or private. It will appeal to school children, to advanced students, to teachers—especially of biology or of science—to the man in the street and, above all, to nature students and to those who love the great outdoors.

T. K. Johnston,
Superintendent of Public Schools,
McKees Rocks, Pa.

Supervised Study

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habit of trying to work efficiently by themselves, *and they need practise as well as advice.*

The writer holds no brief for completely individualized instruction or for anything approaching it. It is a pure waste of teacher service to teach individually over and over again anything that can be taught to the class as a whole, or to any group within it. Purely individualized methods only too often so completely eliminate the competitive spirit, the necessity for social approbation, and the feeling of pressure, that the students actually learns to loaf. The "recitation" half of any class meeting enables the instructor to develop new work economically with the entire group, to clear up common difficulties, to give group tests and group drills. That last word is used advisedly, despite the knowledge that it is anathema to some brethren devoted to the kind of teaching always printed with a capital and quotation marks and called "Progressive." Too often these fail to remember that the "bright child retarded by keeping pace with the group" when put upon a purely individual schedule often forgets almost as easily as he learns, because he lacks repetition and review. He needs, as do the others, to hear, see, feel, and repeat—in short to be drilled for retention. After supervisory experience in a junior high school which for years has divided its time equally between supervised study and class work, the writer is firmly convinced that class work, plus directed study under the eye of the same teacher, combined with a little additional individual instruction, will eliminate failure to a degree practically equal to that boasted by highly touted "Experimental" schools.

For the best results with supervised study, the longer period is recommended. We limit our students to four major subjects, plus clubs and extracurricular activities, and use 90-minute periods, one-half recitation, the other study, in eighth and ninth grades. The seventh graders use hour periods, similarly divided, but there is no valid reason why any teacher who wishes to use directed study cannot carry on using 45-minute periods. Under such conditions she will probably give five to ten minutes to testing, fifteen to twenty minutes to advance teaching, and the rest to independent study; or she may use one day to develop, demonstrate, and help with the text; the next for study and oral check-up; the following one for written fact test and developing advance work; the next for oral check and study, and Friday for review, drill, and summarizing tests. It matters not a whit that she is the only person in her school using the method, nor hers the only grade. It may be used in science without disturbing the English classrooms, or in English without interfering with the science instructor. The fact that her students have had no previous preparation in study methods is one of the strongest arguments for its introduction. Even if her successor does not see fit to continue these methods, her students when they enter that next class will be far better able to help themselves than they were before they had this training. All that the interested teacher has to do is to shift the emphasis from her *testing* of the students to her *teaching and their learning.*

The final level, attainable only by the superior students in these grades, is the ability of the students to make an outline or summary or précis for himself. We say to him, "Read the paragraph. Now write down for yourself only the important *key words* that will aid you in remembering." Suppose we go back to the siphon. These will be U-shape; different length arms; flow toward longer arm; caused by difference in weight of columns and pressure on surface of one container; 34′ limit, etc. Instead of writing questions he puts down key facts, and then *studies his notes.* He must have emphasized to him again and again the difference between "read," to get the general idea, and "study," which means "master to retain." One thing the instructor stresses again and again with individuals who are inclined to loaf: "You are building *habits.* Build good ones or you will be sorry, very sorry, all your life." The class is advised: "Begin studying *at once;* concentrate; don't look up at every little interruption; put your hands over your ears if you feel that this is necessary." At the same time the skilful instructor will be careful to remove as many causes of distraction as possible.

In schools where heterogeneous grouping is the plan, this last study level will be reached only by a small group of superior students in each class, who may be able to work independently. These are the people who will get most of the "Read and report" assignments, while the rest of the pupils are studying on level one or two. When homogeneous grouping is used, practically all of the "rapid progress" group, and a portion of the "average progress" section will reach this level. In junior high school at least, the "slow progress" groups will practically always need daily help in studying the assignment with outlines, though they also must be trained early in the term to "write down the hardest answers and study them longer." The reader is asked to note particularly that *in all supervised study what the instructor is doing is calling the pupils' attention to the new things which they do not know, and helping them to see what they are to study.* Supervised study is not cramming the student, nor preparing him for examination. It is helping him to work by himself, and to form his own conclusions about what he reads.

Many excellent teachers may feel with some justice that in these articles undue emphasis has been placed on the use of text. There are two reasons for this emphasis:

(1) While demonstration and experiment are vitally necessary, the technique of handling them seems to be better understood by the average science teacher than the procedure in training to study.

(2) When these students leave our classes, practically all of their adult education will be carried on through their own reading. They must learn to use texts and reference material in school or not at all. The technique of training in the use of reference material

is too large a question to be taken up here. In the average class most of the use of this supplementary material will be done by the higher mentality groups, *but all groups should master at least one text.* When they have finished the course, the progress they have made in and through that text is a visible proof, both to them and to their parents, that they actually have accomplished something.

To a very great degree, supervised study does away with that old bugbear, "Unprepared." The time to study is given, and if it is not properly used, the teacher in charge has only herself to blame. "The teacher has not taught until the students have learned." If his assignments are too long, the instructor will soon find it out. Many a teacher who has never supervised his own study periods will be surprised—and shocked—to see how vainly children struggle, and how long a time some of them have to devote to an apparently "easy lesson." It is no wonder that many of them give up in disgust, the only wonder is that more do not. The instructor who supervises his own study periods will soon cut the length of assignments, and also the daily amount of written work required. The writer feels personally that no written work *except that done voluntarily by the student in making his own study notes* should be assigned for out-of-class work. Are you assigning written work for teaching purposes or for testing? If it is designed to test the student, it is a temptation to cheat. Testing should be done in the classroom under the teacher's own eye. If it is designed just to keep him busy, and to prove that he really worked, there are many more useful and successful devices for filling his time. *If he KNOWS that he will be tested, he will work.* If the written work is assigned for teaching purposes, then the student should be the judge of what and how much he needs to write down, and it is pure waste of time to check his rough notes, except as it is done casually in the study period.

Where is the teacher during the independent study period, and what is he doing? He is not at the desk, marking lesson papers, nor putting standings into a class book. Supervising study is not merely policing a study hall, but for the last ten minutes of the study period, when there is the greatest danger that time will be wasted, that teacher should be on his feet. The girl working so diligently over in the corner is apt to be writing something beginning "Dear Jim." That industrious boy may be formulating his answer instead of doing a theme, though the chances are more in favor of his drawing cartoons—but not if the teacher is moving quietly about the room, asking a timely question here, making a constructive suggestion there, checking headlines, margins, spelling, neatness of formal written reports, in short, *preventing* failure. The student to whom the study hall teacher says at the end of a period, "Copy that paper; your headlines and margin are wrong," has a perfect right to be angry. Those errors should have been noted, and that copying ordered, before that paper was scarcely more than begun.

"My students don't study, they don't know how to use a book"—"They have no ability to distinguish between major and minor items in a paragraph"—"I gave them an outline but they couldn't use it"—"It just seems as if I couldn't *stand it any longer*." You have heard it dozens of times in the Teachers' Room. So have I, but my completely unsympathetic rejoinder is, "Of course they can't—*but it's because you haven't trained them!* It's our job to take these children as they are, and make them into what we think they ought to be. Our job isn't standing them—it's changing them. Let's get busy!

Safety in the Laboratory

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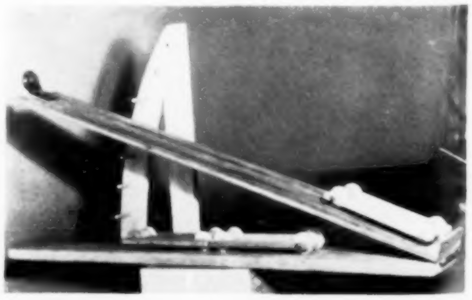
In order to exercise a proper degree of vigilance, the teacher must have a knowledge of his subject. He must know how to eliminate the hazards involved in its practice. The writer has heard of an instance where the instructor, although knowing that chlorates are explosive when mixed with sulfur or other reducing agents, handed out a sample of potassium chlorate for some simple tests designed to show something about its composition. One of the tests required the use of sulfuric acid and the explosion which followed not only showed something about the composition of potassium chlorate but also demonstrated quite effectively how it behaved when acted upon by certain mineral acids. The moral is that a little knowledge may go a long way but sometimes not far enough.

Many high school teachers are required to teach chemistry when they are inadequately prepared for the subject. It is surprising how well they accomplish their task and institutions of higher education are discovering that high school training is not to be disregarded in evaluating a student's ability for further work. Teachers who are not primarily prepared for chemistry can make their laboratories safe by carefully studying their experiments from the standpoint of safety.

An instructor in chemistry should always remember that safety is preferable to first aid. "An ounce of prevention is worth a pound of cure."

A Science Project



An inclined plane constructed by Robert Madden, Ursuline High School, Youngstown, Ohio.

The Science Demonstration

Continued from Page Forty-one

the confidence of the class in subject and teacher. There is no surer way of losing this confidence than to explain that the experiment should have given a different result from the one obtained.

An important means of holding sustained attention and insuring comprehension is to tell the class what you are doing at every step. If we recall how often in our own study "It is evident" has been an author's shorthand for a long stretch of reasoning or calculation, we will not inflict this or similar phrases on our immature and suffering students. The opposite failing is explaining beforehand just what is to happen. Properly used suspense is quite as valuable as in a play or story. An inductive approach by careful questions, leading the class to develop one or more hypotheses and then using the experiment to test the hypotheses, is so important and familiar a tool of scientific method that it seems almost superfluous to mention it.

Professor W. S. Franklin was one of the great teachers and demonstrators of the immediate past. His book, "A Calendar of Leading Experiments," is one of the few real contributions to the literature of the demonstration. Its great virtue is that it stresses not what to do, but what to say as you do it. Tyndall's "Heat as a Mode of Motion," "Sound," and "Forms of Water" should be on the shelves and again and again in the hands of every science teacher. Not only are many of the experiments unrivalled, but the clarity and forcefulness of the presentation account for the throngs which crowded his lectures. There is no better model for the coordination of hand and tongue.

If it seems that the apparatus on the table and the teacher behind it have had too much space in this presentation, it is because the author assumes that his readers are not like a visitor he once had who was a student (?) in an institution for teacher training. When I explained to him something of our demonstration methods, he brightly said: "Ah, the inductive method!" When I assured him that we were not so much concerned with the method as with teaching the pupil, he remarked, "Oh, to teach the pupil, that is a new idea."

It is not to any of us a new idea, it is *the* idea. Every move and every word of the demonstrator must be motivated and conditioned by the constant thought of those on the other side of the table. If this is our frame of mind, we will not make our demonstrations Lectures. I have already referred to stirring the class with inductive questions. This is only the first part of the story. If a demonstration does not evoke questions *from* the class, it is a failure. While the question of time enters here, as it does, alas, in all our teaching procedures, the real test of our success as science teachers lies in stimulation to student activity. It is this participation that leads to assimilation and growth as distinguished from the lethargy resulting from forcible feeding.

In this connection the question arises as to when and how much the students should participate in handling apparatus. The somewhat wide differences of opinion on this problem arise, I think, from considerable differences of conditions. It would seem to follow from what has been said in regard to preparation and familiarity with the apparatus used, that pupils should assist in operations which are simple in themselves, and not likely to disturb or injure the apparatus. An example is the reading of scales, which may not be visible to those in the back seats. Another is tabulating results in simple quantitative experiments. The reactions of a boy who picks a nail which has just been hammered, or runs his finger up the side of a beaker of cold water which has an electric heating coil immersed near the upper surface, make a lasting impression on both boy and class.

The smaller the class, and the fewer classes there are in the subject, the greater the amount of student participation in the experiments which may be profitably used. This is one place where the small school has a greater advantage, and is a compensation for the difficulties of the teacher who occupies a settee of sciences instead of a chair in science. In a large city high school, where section succeeds section in the demonstration room throughout the session, there is a limiting condition in the fact that the rights of the classes to follow must be safeguarded. While it is always imperative that casual handling of carefully prepared apparatus must be prevented, with a succession of classes authorized student aid should not imperil the usefulness of the apparatus in the periods to follow. In a word, student participation in demonstrations should be as extensive as circumstances permit. The real places to train students in experimenting are in the laboratory, the project room and the science club.

After the experiment, what? First, a brief, systematic report in a notebook, with a simple, labeled line drawing, and a discussion or conclusion directed by pointed questions. This should be written after, not during, the demonstration; otherwise attention is divided during the experiments. To this end, a mimeographed or printed guide is a help, but too great for-

mality or regimentation should be avoided. The note book is a means for scientific growth, not an end. Second, class discussion of the experiments should involve not merely oral or board reproduction of the reports, but real training in scientific method, during which the experiment finds its proper place in leading to generalizations, or more often, in interpreting them.

The way of the demonstrator may be hard sometimes, but he reaps an ample reward if his pupils find science a living, growing subject, interpreting and enriching their lives, instead of a dry catalog of obscurely stated and imperfectly understood laws, or an exercise ground for mathematics.

Education as a Science

Continued from Page Forty-nine

more natural "discipline" based rather on interest than on penalties and coercion; the adaptation of the curriculum to the capacities of pupils; the best branches for developing abilities; differences between capacities of boys and girls; the training of the moral faculty through motives, ideals, codes and exercise; the prevention of mistakes by providing exploratory courses where the pupil may try out his abilities without undue loss of time and credit; an increasing amount of technical and industrial training with a resultant abandonment of many cultural subjects as mandatory. The Science of Education has produced both subjective and objective efficiency in the class-room through the so-called "new-type" testing. You are familiar with the Standardized, the Survey, the Prognostic, the Diagnostic, the Binet-Simon, Army Scale, Alpha, Beta; National Intelligence tests, Haggerty tests, Yerkes, Thorndike, Terman, and Otis tests; the Ayres scale for handwriting and so on. The study of educational statistics and measurements presents complex but very useful information for scientific teaching.

In a practical sense, the scientific study of education during the past century has resulted in highly organized State School systems and a decided improvement of normal school professional training in colleges and universities. Our school buildings conform to the latest scientific specifications and are conducted under business methods and management comparable to the most efficient industrial organizations as to finance and personnel. Due to methodical procedure and scientific intensification, the character of the teaching profession has been greatly improved, and more intelligent consideration has been given by the public to the problems of local school organization, supervision, textbooks, methods, the competency of teachers and to the broader subject of education as a matter of public policy: As witness the various school plans as community experiments that have been adopted in the past two decades, with

varying degrees of success; The Dalton, the Winetka, the Curtis and the Morrison Plans.

Not the least important phase of this general will to organized progressivism is the influence exerted by the Government Commissioner through the Bureau of Education at Washington. Through the facilities of this coordinating agency, the efficient methods of class-room management successfully applied in any part of the country are made available to all teachers by means of the publications issued by the Government Printing Office. I recommend the use of this scientific medium for the most forward-looking developments in education and teaching.

As teachers you are no doubt familiar with the bulletins, charts, graphs, tests and visual aids which many independent publishers and supply houses furnish upon request.

Education as a Science has grown into the national consciousness through State and National Education Associations and the erudite studies emanating from their conventions. Exchange of ideas and discussion of methods are healthy signs of systematic interest in the furtherance of child welfare and school management. As a corollary of associated activity, we have learned the utility of the moving picture, the radio, cooperative shop enterprise, project construction, and junior sociological and scientific magazines in guiding youth to a more wholesome interpretation of life and happiness.

I have discussed but superficially the immeasurable possibilities and results of science and the scientific principle in education. Our contention is, therefore, that education viewed scientifically has a profound effect on educational progress, and that no teacher can claim title to progressivism unless she familiarizes herself with the systems, methods, devices and aids which are the gifts of Science.

The Preserving of Food

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ever known. It was he who stimulated this method of preservation by offering a prize to anyone discovering a practical and satisfactory process for preserving foods. The prize was awarded to Nicholas Appert in 1809 for his method whereby food was heated and enclosed in a glass bottle and heated again. This is one of the first experiments with the heating process. Following Appert we find Gay-Lussac and Louis Pasteur, both Frenchmen, giving us still more practical means of preserving foods.

When food is heated, most of the injurious microörganisms are destroyed; spores and some vegetative forms of bacteria remain, but these produce no ill effects. Some foods which are to be stored for a short while are preserved more successfully if cooked; while others are more satisfactory if left raw. Meats which are to be kept over a few days should be cooked. Heat coagulates the meat fibers and makes them less susceptible to bacterial action. Vegetables which are to be

kept should be left raw, since heating breaks down the cellulose, giving bacteria easy access.

In cooking foods, one should be careful to do the least possible harm to vitamins. For example, vitamin A is not destroyed by ordinary cooking, but prolonged cooking destroys it; vitamin B is easily destroyed by heating; vitamin C is destroyed if heated in the presence of oxygen; vitamin E is rather stable so far as heating is concerned, and vitamin G is very stable. Thus we see that a knowledge of how to cook foods for preservation is essential.

Heating, as we have seen, sometimes destroys vitamins. Such destruction detracts from the nutritive value of the food. On the other hand, bacteria are, as a rule, almost completely destroyed by heating, whereas, in refrigeration, their action is merely retarded.

Both of these methods appear to have reached perfection and will remain for centuries as monuments to the men who made it their life work to give humanity an efficient means of preserving food.

Although it is evident that both heating and refrigeration are effective in the preservation of foods, refrigeration is the more common method because it is by far the more practical.

Science at High School Level

Continued from Page Forty-six

has as its main purpose the development in the mind of the pupil of an important concept of science or the understanding of some important principle or group of principles. Each unit is introduced to the class through a discussion that is intended to make clear the nature and extent of the material to be studied, its importance, and its connection with previous work. Then, each pupil is "put on his own," and there follows a period of study during which books in both the classroom and the general school library are consulted, demonstration and individual experiments are performed, problems are solved, excursions and field trips are made. Most important of all, during this period of exploration, through further discussions and supervised study, the individual difficulties of each pupil are given close and careful attention. On occasions of school inspection one frequently hears the criticism that the teacher lectures too much and that the process of bringing out the latent possibilities of the individual pupil is not being carried out. It seems this method of "putting each student on his own" will help considerably in overcoming the fault of "lecturing too much." When sufficient time (it will vary somewhat with the individual classes and pupils) has been given to the period of exploration, appropriate tests may be given to determine when the pupils have attained a satisfactory understanding of the material. Other activities designed to aid the pupils in organizing and expressing their newly acquired knowledge will then be in order. Special interests may be taken into account through voluntary undertakings and through the activities of a science club.[6]

All of the science courses should be so arranged as to carry full units of credit; i.e., three hours of lecture (as it is ordinarily called) per week and two two-hour periods of laboratory per week for 36-38 weeks. Many of the experiments in Science I could be given very well by demonstration.

In offering these units of the various science courses it is well understood that the matter of curriculum-making should not be carried out by one person in a short time. On the contrary, such a study should be directed by the concerted efforts of a committee over a long period of time (at least several years). With this in mind these units are suggested merely as a beginning; and it is hoped that, as the various units are taught, newer and better ideas will come to light. Time and space are not available to develop fully each of the given units—to analyze each into its four or five elements, to prepare guide sheets, outlines of presentation, and tests. To do this properly requires fifteen to twenty hours for each unit.

The author does not wish to impose on a group of teachers any single system of presenting science topics and principles in preference to others; but merely, to state that in his experience the unit of understanding (with modifications to make adjustments for existing conditions in administration, in the laboratory, in the library, and in the actual arrangement of the class rooms) has been more efficient (even in college classes) than others he has tried. The point is: some system that takes into account the individual difficulties of the pupils is better than a system that neglects this very important educational factor.

SCIENCE I.

(1) How the Earth Came to Be as It is Today—Geology and Meteorology.
(2) Matter—Classification of Material Substances. Survey—very elementary in nature—of modern concepts of matter.
(3) Chemical Transformations of Matter—Nature and Control of Fire. Fuel values and newer types of fuel.
(4) Transformations of Matter (Physical)—Condensation and Evaporation of Water. Refrigeration.
(5) Energy (Work)—Harnessing Nature to Do Man's Work. Electricity and Its Uses in Modern Life—Communication and Transportation.
(6) Water Supply of Modern Cities and Homes. Sewage Disposal.
(7) The Work of the Body.
(8) Man and Microbes.

SCIENCE II.

(1) The Obtaining of Food Necessary for Physical Life of Plants and Animals.
(2) Use of Food Necessary for Plants and Animals.
(3) Growth of Plants and Animals.
(4) Reproduction (Lower Phyla).
(5) How Do Plants and Animals Live Together?
(8) Behavior of Living Things.
(6) Classification of Plants and Animals. } Evolution.
(7) Distribution of Plants and Animals. }

Optional units may be given on: Heredity, Adaptation, Eugenics, Conservation of Life, Evolution.

SCIENCE III.

(1) Measurements of the Properties of Matter. This will include density, pressure, weight, etc., and introduce the metric system. The Molecular Constitution of Matter.
(2) Heat and Temperature.
(3) Mechanics of Fluids (Liquids and Gases).
(4) Mechanics of Solids.
(5) Static and Current Electricity.
(6) Magnetism and Electro-magnetism.
(7) Light.
(8) Sound.

SCIENCE IV.

(1) The Periodic System.
(2) Chemical Change and the Atomic Constitution of Matter.
(3) Reaction Velocity; Reversible Reactions; Chemical Equilibrium.
(4) The Theory of Solutions—Ionization.
(5) Oxidation—Reduction in Terms of the Electron Theory.
(6) Identification of Chemical Substances—including inorganic chemistry of the metals.
(7) Carbon and Some Carbon Compounds—including some aspects of modern biological chemistry; e.g., vitamins, enzymes, hormones, etc.
(8) Some Commercial Applications of Chemistry—The Frasch Method; Haber Process; Birkland-Eyde Process; Fixation of Nitrogen; Deacon Process; Solvay and Le Blanc Processes; Contact and Lead Chamber Processes for Manufacture of Sulphuric Acid. Some Electrolytic Processes.

Science Teacher

As a rule the schools and colleges that offer courses for the training of teachers of science focus the attention of the pupils upon some particular field of science, such as chemistry or biology. Teachers themselves, when asked if they are science teachers, usually reply: "I am the chemistry teacher," or "I am the biology teacher." Rarely in high school circles does one meet the teacher who can say: "I am the science teacher." Yet, particularly in the small school (the school of one hundred pupils), there is need of the teacher who is equipped to handle any one of the biological or physical sciences at the high-school level. And this is really not asking too much of one teacher.

Michigan State Normal College at Ypsilanti, Mich., recognizing the need for teachers so trained, was one of the first educational schools to offer a course for the training of high-school science teachers.[7] A suggested curriculum offered in the fall of 1933 at Ypsilanti, contained the following *minimum* requirements in science:

Subject	Term Hrs.
General Chemistry	8
Qualitative Analysis	4
Organic Chemistry	4
Botany	8
Zoology	8
Physiology	4
Geology	4
College Physics	12
Astronomy	4
Teacher Training in Science	4

Of course, other subjects go to make up the complete course for the training of the science teacher.

Many of the high schools conducted under Catholic auspices have an average enrollment of two hundred or less; and, therefore, cannot afford to have on the faculty more than one or two science teachers. Furthermore, in addition to their training in science, teachers who are members of religious orders, must receive training in subjects required by the Studium in preparation for the priesthood, brotherhood, or sisterhood. In the event that science be offered in each of the four years of the high school and only one science class be necessary in each year, some thirty hours of science should be taught each week. This is more than the average load of one teacher; and, a second teacher, who could also carry most of the mathematics taught, would be required.

It is desirable that those preparing to teach science in the high schools obtain a B.S. degree. Then, after teaching for 2-3 years in high school with a B.S. degree, it would be well were they permitted to obtain at least a Master's degree in one of the special fields of science at a first-rate college or university. Perhaps the best reason for the 2-3 years of teaching experience is that present needs are to be satisfied and no time should be wasted in filling the present high school positions. Moreover, after a few years of actual teaching experience, one should grasp more readily the subject matter at hand and understand more thoroughly the methods of study.

By reason of the requirements of the Studium and of the different institutions of learning for a B.S. degree, it is a difficult matter to state definitely just what should be demanded of the student in the way of undergraduate training in the preparation for the priesthood, brotherhood, or sisterhood and for high-school science teaching. E. R. Downing has listed the requirements for teaching science in the several states, and these should not be overlooked in preparing students to teach science.[7] Then, again, it is desirable that our high-school teachers have as liberal an education as possible and, in planning a science-teacher-training course, one should overcome the tendency to favor the science subjects more than the humanities. If time were available, the solution of the problem seems to be the offering of a B.A.—B.S. course, the requirements of which can hardly be fulfilled in any less than five years (excluding summer sessions). In order that a beginning may be made, the following suggestions as to *minimum* requirements are offered.

Subject	Semester Hrs.
Principles of Religion (including socio-religious problems and life problems)	16
English	12–20
Latin	12–20
German (or French)	8–20
Philosophy and Social Sciences	12–15
Education and Educational Psychology (including methods)	18
Botany	4
Zoology	4
Physiology	4
Bacteriology	4
General Chemistry	8
Qualitative Analysis	4
Quantitative Analysis	4
Organic Chemistry	4
College Physics	12–15
Mathematics (including Algebra, Trigonometry, Analytic Geometry, Calculus)	12–20
Elective (according to local requirements)	10
Total	148–199

Other Aids

In all probability the best list of representative books for the high-school science library is the one compiled under the direction of H. A. Webb and reprinted from the Peabody Journal of Education, Nashville, Tenn.

Under the heading of "other aids" for the improvement of science instruction, one should not omit to name certain current periodicals in the field of science and to indicate their usefulness.

Journal	Usefulness
National Geographic Magazine	Of General Benefit
Nature Magazine	General Science and Biology
School Science and Mathematics	General Science and Physics
Journal of Chemical Education	Chemistry and Teaching Methods
Science Education	Teaching Methods
Science Counselor	Methods and General Information

There are many devices for enriching the courses in science such as movies, slides, models, charts, exhibits, projects, essays and science clubs[9].

It will be well to give, also, a number of important references for the teacher of high-school science. In Downing's book[10] (pp. 39-48) are given the principles of biology, physics, and chemistry. And, for one interested in research studies relating to the teaching of science, reference to Science Education[11] will be of great assistance.

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